OFFICE OF THE QUARTERMASTER GENERAL
DEPARTMENT OF THE ARMY

THE PETROLEUM HANDLING EQUIPMENT RESEARCH AND DEVELOPMENT PROGRAM OF THE DEPARTMENT OF THE ARMY

ANNUAL REPORT

QUARTERMASTER RESEARCH & DEVELOPMENT COMMAND

DECEMBER 1956

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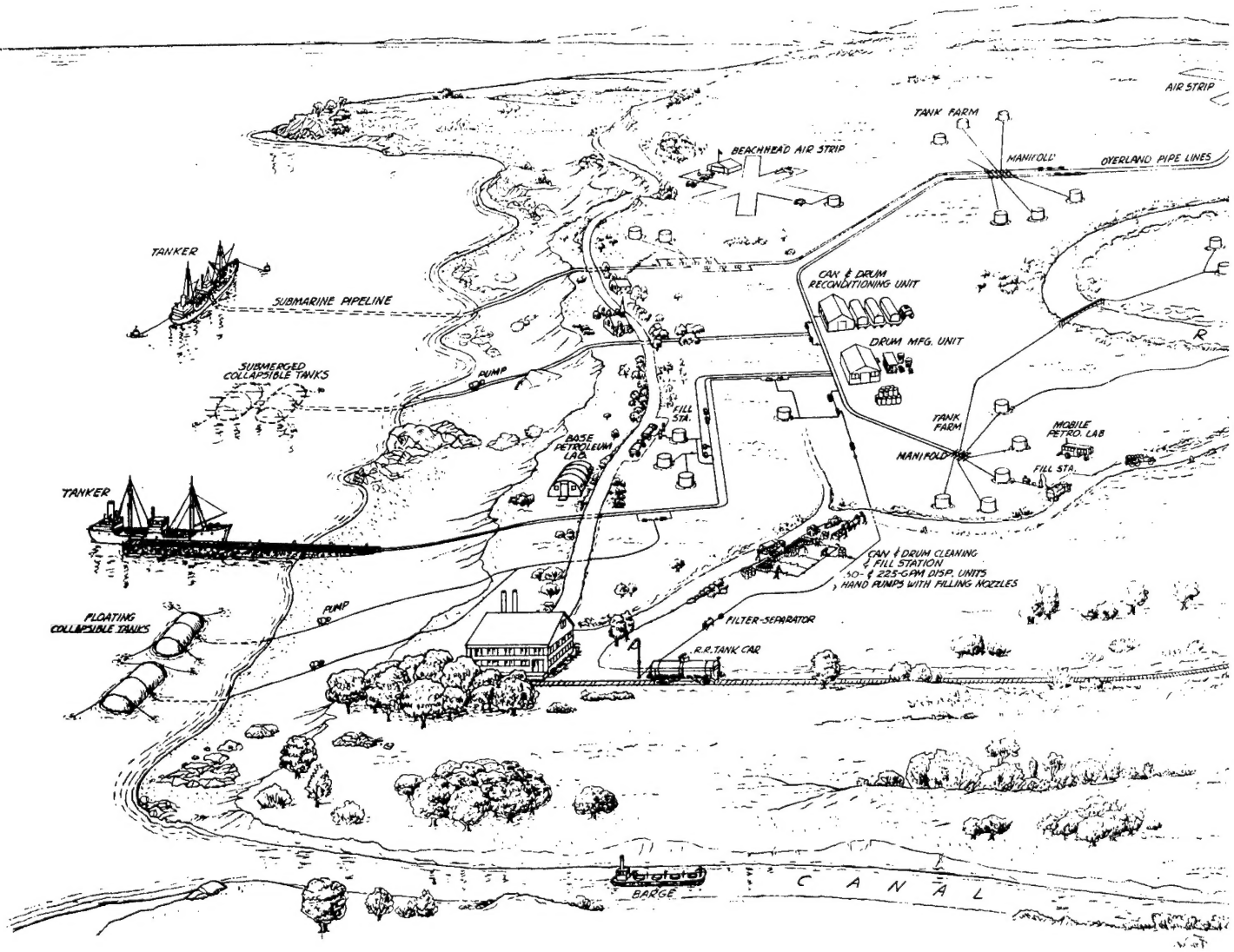
THE PETROLEUM HANDLING EQUIPMENT RESEARCH AND DEVELOPMENT PROGRAM OF THE DEPARTMENT OF THE ARMY

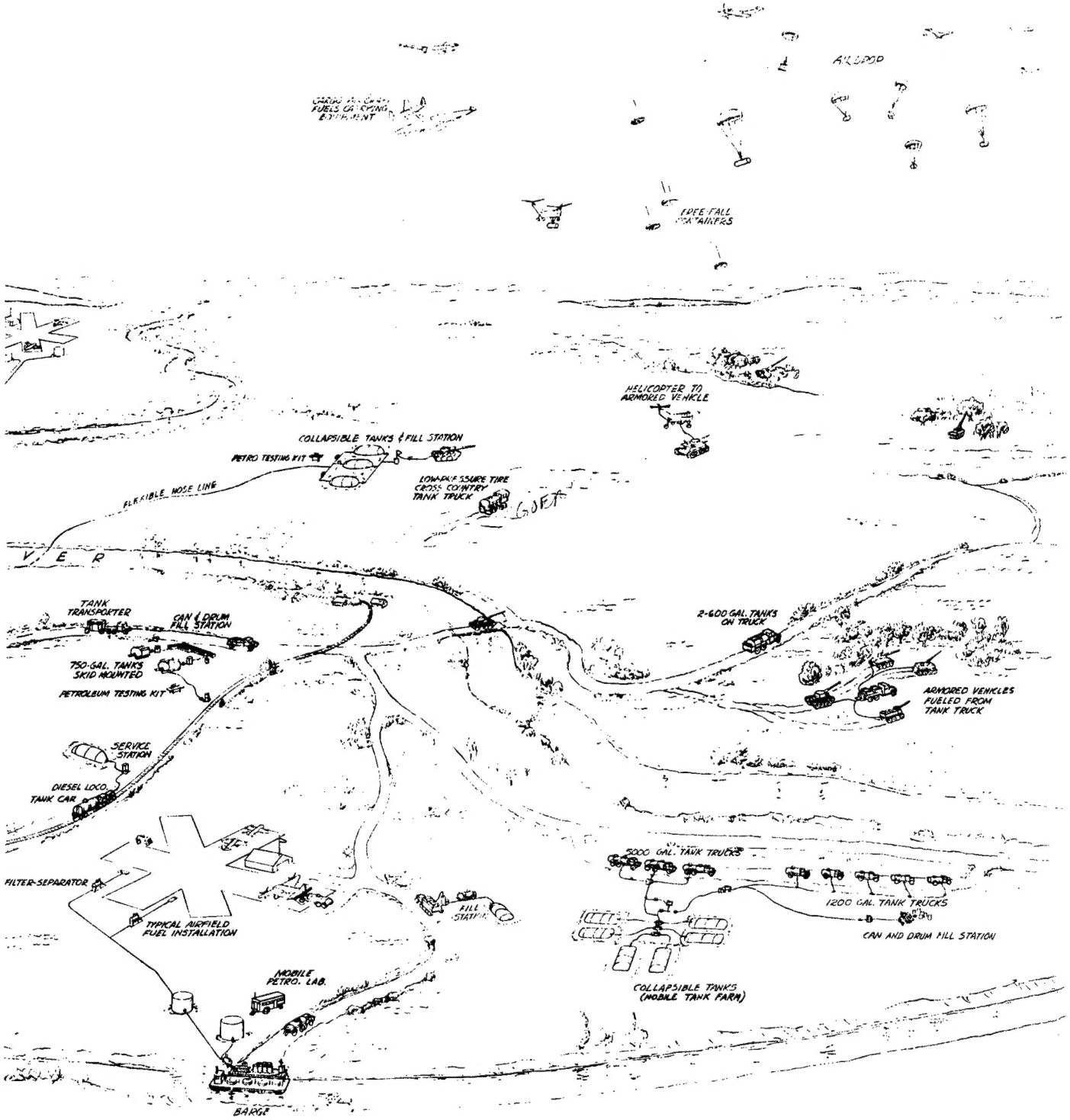
FIRST ANNUAL REPORT

OFFICE OF THE QUARTERMASTER GENERAL
DEPARTMENT OF THE ARMY

DECEMBER 1956

ELEMENTS OF A P.O.L. SYSTEM WITHIN A THEATER OF OPERATIONS




AIRDROP
FREE FALL CONTAINERS
HELICOPTER TO ARMORED VEHICLE
COLLAPSIBLE TANKS & FILL STATION
PETRO TESTING KIT
FLEXIBLE HOSE LINE
LOW-PRESSURE TIRE CROSS COUNTRY TANK TRUCK
TANK TRANSPORTER
CAN & DRUM FILL STATION
750-GAL. TANKS SKID MOUNTED
PETROLEUM TESTING KIT
2-600 GAL. TANKS ON TRUCK
ARMORED VEHICLES FUELED FROM TANK TRUCK
SERVICE STATION
DIESEL LOCO. TANK CAR
FILTER-SEPARATOR
TYPICAL AIRFIELD FUEL INSTALLATION
5000 GAL. TANK TRUCKS
1200 GAL. TANK TRUCKS
CAN AND DRUM FILL STATION
COLLAPSIBLE TANKS (MOBILE TANK FARM)
MOBILE PETRO. LAB.
BARGE

ABSTRACT

The Department of the Army must be prepared to supply our fighting forces with vital petroleum products under all possible circumstances in any part of the world. To accomplish this mission in the most efficient manner and with the greatest possible economy, an extensive research and development program has been undertaken. The various Technical Services have made very significant progress in the development of improved equipment and techniques for storing, transporting, dispensing and testing fuels and lubricants. During the past year outstanding progress was made in the following areas:

The essential elements of the above-ground pipeline system have been completed, and further developmental work in this area will be at an absolute minimum.

Emphasis has been placed on accelerating the development of the flexible pipeline system, and a system of this type is presently being assembled for evaluation.

New techniques for rapidly off-loading large tankers under all tactical and hydrographic conditions, capable of being put into operation speedily, are in the process of development. These improved techniques are made necessary because of increased tanker capacity, the need for sustained high receiving rates and the vulnerability of fixed marine terminal facilities to mass-destruction-type weapons. The planned program includes such items as offshore tanker moorings, floating and submerged storage base terminals, submarine unloading lines, offshore pumping equipment, prefabricated marine POL terminals, and ship-to-shore high-pressure hose.

The development of large-capacity (25,000 to 50,000 gallons) collapsible floating storage tanks designed for use in support of operations by water-based aircraft has been initiated.

A kit to convert the Barge, Cargo Deck, Non-propelled, Steel, 81-foot, to a liquid cargo barge for use in harbors or on rivers has been type classified as standard.

The development of a 55,000-gallon gasoline steel tank for bulk storage of POL is nearly completed.

Design and development of a family of cargo kits for use in transporting bulk fuel on cargo, tracked vehicles and aircraft with emphasis on lightweight equipment of simple design has been initiated, and several prototypes are presently undergoing test.

Prototypes of a replacement item for the present standard M131A1 5,000-gallon gasoline semi-trailer, which exceeds allowable bridge limitations and state highway limitations in CONUS, have been procured for engineering tests.

Development of a family of flexible or collapsible containers for multi-purpose use in the delivery and storage of bulk fuels has been initiated and will continue to be expedited.

These and numerous other significant accomplishments have contributed importantly to the development of greatly-improved methods of handling and dispensing POL products. Work on the development of an integrated POL system is being continued in order to insure that all military petroleum requirements will be efficiently met.

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PREFACE

This is the first formal report by the Department of the Army on its research and development program in the field of Petroleum Handling Equipment. It includes a resume of background, current status and future plans for the development of equipment for use in an integrated system of POL distribution from the Zone of the Interior to the combat forces.

This system is supported basically by equipment supplied by the Quartermaster Corps, Corps of Engineers, Transportation Corps, Ordnance Corps and Signal Corps. Logistics responsibilities are assigned in Army Regulation 701-9100-1, dated 18 February 1955. Excerpts from this Regulation, outlining responsibilities assigned to those agencies, are quoted below:

1. Quartermaster Corps. The Quartermaster Corps

"a. Administers the Department of the Army development, procurement, and supply system, except as indicated herein and in SR 700-51-100 series, for petroleum products and related equipment. At the theater level, the responsibilities enumerated herein, where applicable, will be assigned to the Theater Quartermaster.

"b. Prescribes methods and procedures for the computation and submission of requirements for petroleum products.

"c. Prepares programs and studies for the Deputy Chief of Staff for Logistics or higher authority on matters affecting availability, supply, distribution, storage, procurement, maintenance, and conservation of petroleum products and related Quartermaster equipment.

"d. Determines phased petroleum product requirements and bulk storage requirements.

"e. As the technical service having dominant interest within the Army, prepares coordinated broad plans and policies for the supply and distribution of petroleum products. These coordinated plans and policies state the phased requirements for petroleum products, the points at which these petroleum products are to be stored and/or delivered to the user, and means of delivery to those points (for example, pipelines, and/or other methods.)

"f. Contracts for services rendered by commercial owners of petroleum dispensing and storage facilities and pipeline systems.

"g. Operates testing laboratories to maintain quality control of petroleum products.

"h. Operates plants for reclaiming, manufacturing, fabricating, and filling (except those for specialty items specifically assigned to other technical services) standard-type petroleum containers assigned to the Quartermaster Corps. Arranges through prescribed procedures for services of commercial facilities to perform these functions, as required.

"i. Operates the petroleum distribution systems including --

(1) Off-vessel discharging and loading facilities, such as submarine pipelines, submarine hoses, dock and other manifolds, and booster pumps.

(2) All petroleum bulk storage facilities, both fixed and portable.

(3) Pipelines, pumps, and other related equipment within or between storage installations or extending to using agencies.

(4) Petroleum dispensing facilities or equipment.

"j. Collaborates with other agencies in research and development of new and synthetic petroleum refining and processing methods.

"k. Provides and operates petroleum tank trucks and tank trailers utilized in the local distribution of petroleum products. Operation of such equipment which is organic to units will be the responsibility of the unit concerned.

"l. Performs organizational maintenance on Engineer petroleum pipeline equipment. Organizational maintenance (Quartermaster) on the petroleum pipeline system is defined as follows:

(1) Minor repair work, cleaning, preservation, lubrication, scheduled preventative maintenance and minor adjustments; external and internal cleaning, including ventilating, calking, and peening of bolted tanks; and maintenance of camouflage.

(2) Unit replacement of exposed sections of grooved type pipeline and couplings, repair of small leaks and bolted clamps; and other repairs not involving construction or special handling equipment.

(3) Repair or replacement of such assemblies not requiring the basic equipment to be evacuated and which can be performed with authorized tools and equipment.

"m. Performs the internal cleaning of rail tank cars, tank trucks, and tank trailers."

2. Corps of Engineers. The Corps of Engineers

"a. Designs petroleum pipeline systems and petroleum bulk storage facilities.

"b. Prepares plans and costs analyses covering construction and maintenance (except organizational maintenance) of pipelines, bulk petroleum storage facilities, off-vessel discharging and loading facilities and fixed dispensing equipment.

"c. Determines the requirements for construction of pipeline systems, bulk storage facilities, and fixed dispensing equipment, to implement approved plans for the supply and distribution of petroleum products.

"d. Constructs pipeline systems, bulk petroleum storage facilities, off-vessel discharging and loading facilities, and fixed dispensing equipment.

"e. Performs field and higher maintenance on bulk petroleum storage facilities, pipeline systems, off-vessel loading and discharging facilities and fixed dispensing systems. Field and higher maintenance (Engineer) on the petroleum pipeline system are defined as --

(1) Repair or maintenance which requires the equipment to be moved from the site.

(2) Repair or maintenance which requires special tools or welding equipment.

(3) Overhaul of pump unit which requires removal of pump cover, or removal of engine.

(4) Repairs or reconstruction necessitating the use of special construction equipment or techniques.

"f. Rehabilitates, constructs, maintains, and operates petroleum drilling, producing, and refining facilities.

"g. Installs and maintains (except organizational maintenance) fixed can and drum manufacturing, drum cleaning and reclamation, and drum filling equipment.

"h. Installs service station type pumps and related equipment in new construction projects.

"i. Performs and provides funds for the research and development of fuels and gases used exclusively for cooking and space heating, asphalt, paint thinners, and solid fuels."

3. Transportation Corps. The Transportation Corps

"a. Provides for the movement by military or commercial means, except pipeline and local distribution of bulk and packaged petroleum product.

"b. Prepares plans and cost estimates covering (a) above."

4. Ordnance Corps. "The Ordnance Corps plans, organizes, directs, conducts, and provides funds for research and development of petroleum products and synthetic materials having similar uses including preparation of specifications and qualification testing except as indicated in paragraphs 4j and 7."

5. Chemical Corps. "The Chemical Corps performs and provides funds for research and development of petroleum products used exclusively in the manufacture of chemical munitions which are assigned to the Chemical Corps."

6. Signal Corps. "The Signal Corps provides necessary communication support required for the operation of the petroleum supply system to include installation, field and higher echelon maintenance, extension and reconstruction by Signal Corps troops. Operation of communications equipment will be provided by personnel of the using arm or service, unless size of installation requires support of Signal Corps pipeline communications units. Provisions of this support and command control of a communication system will be in accordance with policy enumerated in AR 105-15."

This is an integrated Department of the Army report and no attempt is made in the text to indicate which of the Technical Services is responsible for each developmental item. The report is based upon information supplied by all of the Services participating in the Department of the Army POL handling equipment research and development program. The assistance of these agencies in the preparation of this report is gratefully acknowledged.

BACKGROUND

Approximately 60 percent of the tonnage which the U. S. Army will have to provide troops in combat areas in the future will be petroleum products. The importance of efficiently supplying petroleum products to our combat forces during a conflict is well established.

The only military petroleum supply system which can be deemed acceptable is one which will assure the supply of products to a combat area under all tactical situations and will be capable of operating under the various global, climatic conditions. It must be flexible so it can be adjusted or modified easily to meet any tactical situation arising, with a minimum of disruption to other military activities.

Basically, there exist four methods of transporting these petroleum products. These methods are: a. ocean transport; b. land and water transport; c. pipelines; and d. air transport.

By having available in the military supply system sufficient types of equipment suitable for delivering fuel by these methods, it will be possible to supply fuel under all tactical conditions. Examples of these possibilities are: a. when sea-lanes are closed; b. when highways are destroyed; c. when highway and railroad bridges over streams, ravines and rivers have been destroyed; d. when terrain is impassable to ordinary vehicles; e. when roads are clogged with traffic to the limit of capacity; f. when our large combat units have penetrated deeply into enemy territory and have been completely enveloped by the enemy forces; and g. when the enemy has superiority in the air.

Efficient utilization of the previously mentioned modes of transportation is required because the delivery of fuel to the using vehicles must be accomplished with a minimum of handling. The use of cans and drums for the delivering of fuel will be required for certain tactical situations, and it appears reasonable that the bulk delivery of fuel can be successfully used in making petroleum products available to the using vehicle. Delivery of fuel in bulk not only decreases manpower requirements but also, due to its limited handling by this method, results in a decrease in contamination problems.

Pipelines are considered to be one of the most efficient methods of transporting petroleum products. Their use in rear areas has proved practical in the past. The extension of the pipelines into combat areas is considered to be a firm requirement. Collapsible piping, capable of being unrolled much like wire cable, making available unlimited fuel supply to combat elements, would be advantageous.

The transporting of fuel by fixed-wing, cargo aircraft and by helicopter is a mode of transportation considered most important, and should

be exploited to the utmost. Distribution of fuel by air should not be considered as an emergency supply method which is to be used under unusual circumstances. It is believed that this is the foremost method of supplying the combat field commander who intends to strike for a decision.

In tactical situations of the following type, supply by air transport is the only practical method to use and will be entirely self-sufficient: a. when our forces have penetrated deeply into enemy territory and the enemy has surrounded us; b. when an enemy attack has resulted in an envelopment of our forces and has destroyed our supply line; c. when a commander has flown in an Army and has struck deep into the vitals of the enemy, to destroy his headquarters, projectile launching sites, supplies, communications, transport and production facilities; d. when an enemy has destroyed our supply installation; e. when the nature of the terrain requires that ground supply must be provided over long, circuitous and easily destroyed routes, or the land supply route would require many miles of winding travel on narrow mountain-side roads for each mile of direct progress forward; f. where time is a great factor.

The above situations give a good indication of the importance of developing efficient methods of transporting fuel by air.

While the design of the cargo aircraft is an Air Force responsibility, close coordination is necessary to assure that cargo aircraft are capable of transporting petroleum products in the quantities required by the Army, and to assure development of cargo aircraft which are capable of take-off and landing on hastily prepared runways of minimum length. Equipment developed by the Army, to be utilized in air transportation, should be kept to a minimum weight and cubage, so that the ratio of payload to flying radius is maintained at a maximum.

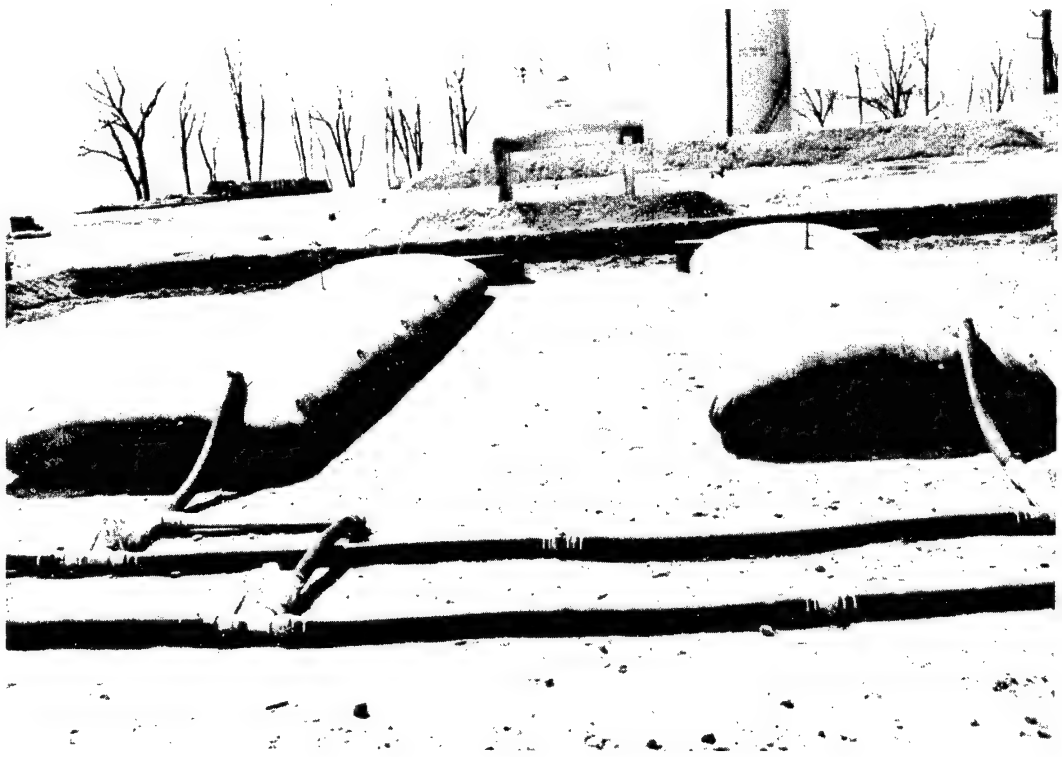
Transporting fuel by air presents problems in addition to those which now exist in transporting fuel on the ground or by ocean transport. Transporting fuel by air in sealed containers is preferable to transporting the fuel in vented containers to the atmosphere, since the sealed method requires no venting provisions on the aircraft, and permits unloading time to be kept to a minimum. However, pressure build-up in a sealed container, due to decrease in ambient pressure with altitude, aircraft "g" forces, and vapor pressure increase due to ambient temperature increase which may occur when storing the fuel on the ground prior to loading the aircraft, require these sealed containers to withstand large internal pressures which, in turn, increase the container weight. This problem can be alleviated by developing collapsible containers having suitable expansion characteristics. Since the use of aircraft for transporting fuel requires careful analysis and planning, comprehensive studies should be implemented to make optimum use of this important mode of transportation.

PART I

POL CONTAINERS

Collapsible Containers. With increasing emphasis on lightweight supply items with the least possible cubage which are suitable for cargo air transport as well as for general field use, the development of collapsible containers has taken on added importance. Until now, rigid steel containers have been used for fuel storage with collapsible containers restricted to limited field operations, as for example, the temporary storage of fuels.

The collapsible containers now in the military system have capacities of 900, 3,000, and 10,000 gallons.



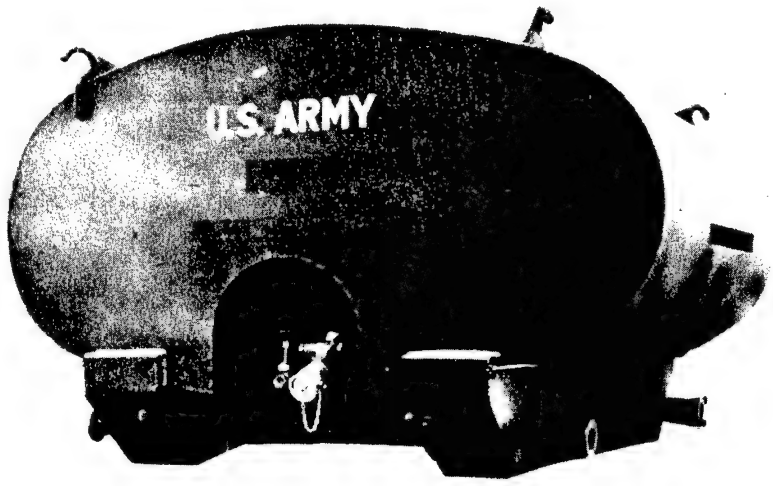
10,000-gallon collapsible pillow-type containers used for temporary fuel storage.

These containers are inadequate for several reasons: they cannot withstand the rough usage they are subjected to during military operations;

the capacities are such that they do not permit efficient utilization of space when used with many military vehicles; and these containers are not suitable for transporting fuel by cargo aircraft in the sealed condition due to high internal pressures encountered.

Because of increased emphasis on the bulk delivery of fuel, a feasibility and design study has been initiated for the development of an integrated family of bulk fuel containers, which will be suitable for use under all military conditions and by all modes of transportation. Emphasis under this development is being given to collapsible fuel containers which can be sealed and transported by fixed-wing cargo aircraft and helicopter. Collapsible containers are expected to have a number of important functions in military storage and distribution of fuel. It is anticipated that much work will be required to make available this type of container with optimum characteristics necessary for versatile military use.

Rigid Containers. Portable rigid containers now in the military supply system consist of the limited standard 750-gallon steel tank, the 55-gallon steel drum, and the 5-gallon steel can.



Portable 600-gallon skid-mounted fuel tank for general field use and conversion kits for the $2\frac{1}{2}$-ton series military trucks.

Containers required for the delivery of fuel by bulk as far forward as possible are currently under development. Although a definite need will remain for the 5-gallon can and 55-gallon drum for use in the packaged delivery of fuel where bulk delivery is not feasible, it is expected that future developments in the bulk delivery of fuel will reduce requirements for these containers.

A 600-gallon tank, which will be used more efficiently with the $2\frac{1}{2}$-ton military truck, has been designed, developed and standardized. The dimensions of this newly developed tank are such that two of them can be accommodated by the $2\frac{1}{2}$-ton truck. At the present time, 600-gallon tanks made of aluminum and magnesium are under development.

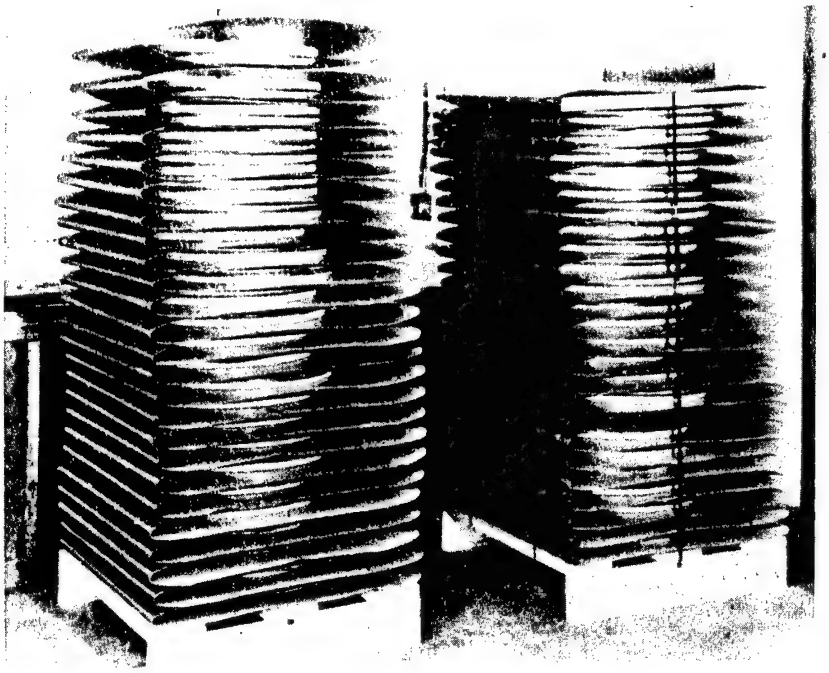
Containers for Packaged Fuel. Considerable emphasis has been placed on the development of equipment suitable for the efficient implementation of the bulk fuel concept. Nevertheless, the delivery of packaged fuel continues to be a firm requirement for use in those tactical situations which do not efficiently permit re-supply of fuel in bulk. Accordingly, projects concerned with improving the packaged fuel concept have continued.

55-Gallon Drums. Experience has indicated that the commercial standard 18-gage drum is not suitable for general military applications. Therefore, a 16-gage drum with reinforced chimes has been developed, and it has generally proved to be satisfactory for use under all tactical situations. In the interest of conservation of steel, however, the use of 16-gage steel sheets is not considered favorable. Also, industry is required to maintain special equipment necessary for the fabrication of 16-gage drums, which results in increased cost to the Government. In an effort to solve this problem, steps were taken to develop an 18-gage drum superior to the commercial standard. Extensive testing, completed in April 1956, indicated clearly that the 18-gage drum of the four-point contact design with flat rolling hoops is superior to the existing standard commercial 18-gage drum. Although its durability does not equal that of the 16-gage drum, the consensus of representatives of the military agencies in a meeting at Washington in July 1956, was that the drum would be acceptable with minor modifications. The latter consisted primarily of reinforcing the chimes with a 14-gage rolled-in ring. Before recommending the standardization of the modified 18-gage drum, it was decided to have the Petroleum Packaging Committee investigate industry's opinion of this item. A report on the findings of this committee is expected in the near future.

Pre-Flat Steel Drum Manufacturing Plant. One of the precautionary measures established to meet a possible national emergency is the maintenance of a large stockpile of 55-gallon drums as a mobilization reserve. Preliminary development work has indicated the feasibility of fabricating a steel sheet into a cylinder, compressing the cylinder, and inserting top and bottom heads and chimes. Machines for expanding the shell,

sealing the head, bottom, and chime, were developed and delivered to Belle Meade General Depot for test in July 1954. The Field Evaluation Agency, Fort Lee, Virginia, completed a logistical study in June 1956.

To date, a total of 9,000 16-gage pre-flat drums have been manufactured. Six thousand of these drums were fabricated from pre-flat condition in 1955; the remaining 3,000 drums were made up in 1956. The original 6,000 drums in final form were subjected to storage tests; the remaining 3,000 were storage-tested in pre-flat form. All of the drums have been inspected and those found acceptable will be placed in depot stock for further evaluation.



Preflattened 55-gallon, 16-gage steel drums for shipping in minimum cubage.

Universal Closure for 55-Gallon Drums. Fifty-five-gallon drums are supplied with closures of two types which are not interchangeable. This not only requires two replacement items in the system, but often results in the use of the wrong item with the consequent loss of product and the creation of a fire hazard. A universal closure that is expected to replace either or both of the commercial items is now under test. This closure will provide a superior seal, thus preventing drums from leaking and fuel contents from being contaminated. Standardization is programmed for FY 1957.

Jerrican (British 5-gallon can). The members of NATO are considering the adoption of the British Jerrican as a standard item of equipment.

Investigation has revealed that in England the Jerrican is manufactured basically in a hand-welded operation, a method of production which would be prohibitively expensive in the United States, due to the high cost of labor. Because of the nature of the joint on the Jerrican and the angles involved, standard resistance welding is not satisfactory. The weld is too close to the edge of the material, and certain portions of the joint cannot be reached with any conceivable revolving seam-welding wheels. A project has therefore been undertaken to develop an automatic welding technique suitable for the fabrication of the Jerrican.

Linings. During World War II, fuel contamination, which made unavailable for use large quantities of fuel, was a serious problem. Extensive study determined that one of the more important factors contributing to the contamination of the fuel was the chemical action resulting from its contact with the inside of metal containers such as the 5-gallon can and the 55-gallon drum. To solve this problem, an extensive research and development program was initiated in early 1949 for the purpose of developing a suitable lining material which would prevent contamination and assure high quality control for stored products. Numerous coatings were investigated and five showed good possibilities of being applicable to the problem at hand. Accordingly, several hundred 5-gallon cans were lined with the most promising coatings and subjected to storage tests for a period of 18 months. These specially-lined cans were filled with water, Avgas, Mogas, and the jet fuels. Periodically, extensive chemical analyses of the stored fuels were made and the linings were examined. In March 1956, these tests were completed and the results were considered successful. Therefore, a production-test purchase description, that is expected to give user experience with the recommended liners, has been prepared.

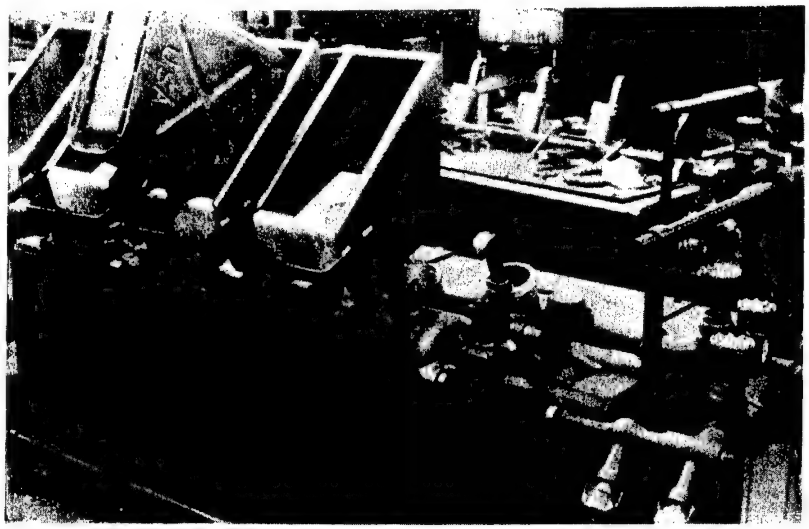
Atom Explosion Test - 55-Gallon Drums and 5-Gallon Cans. The shock wave from an atomic explosion may damage 55-gallon drums and 5-gallon cans in two ways: they may be crushed by the static pressure, or they may be thrown through the air by drag forces. In the latter case, the damage occurs when the can or drum strikes other containers on the ground. Information now available indicates that the drag forces are the more important cause of damage. Studies to determine the velocities that may be encountered are underway, and another test, to obtain information about the damage which occurs when containers come to a final stop is being prepared.

Can and Drum Equipment. During storage, shipment, and supply operation 5-gallon fuel cans and 55-gallon drums are damaged and require reconditioning before they can be reused. Cleaning, reconditioning and filling by present methods, which involves shipping the cans and drums to permanent repair centers, is both costly and inefficient. A research and development program has therefore been undertaken to provide the Army with reconditioning and filling equipment.

Reconditioning Unit for Fuel Containers. A mobile assembly has been developed to de-dent, chain, clean, wire-brush, paint, and test 5-gallon cans and 55-gallon drums at the rate of 60 drums and 120 cans per hour.

Two prototypes have completed user tests in Europe, and a third modified prototype is being user tested in Italy. A decision concerning the type classification of this item as standard will be based on analysis of test results.

Fuel Can and Drum Cleaning Machine. Fuel contamination due to dirt, water, and other foreign materials in 5-gallon cans and 55-gallon drums has been greatly reduced since the development and standardization of



Machine for cleaning 5-gallon cans and 55-gallon drums.

the Fuel Can and Drum Cleaning Machine. Field use of this machine in Korea demonstrated conclusively its value, but also revealed some deficiencies. A project was therefore initiated to modify the standard unit to correct these shortcomings. The modified machine has undergone preliminary and informal tests and is now ready for engineering tests. Results have been satisfactory and specification changes will be made to adopt the necessary modifications.

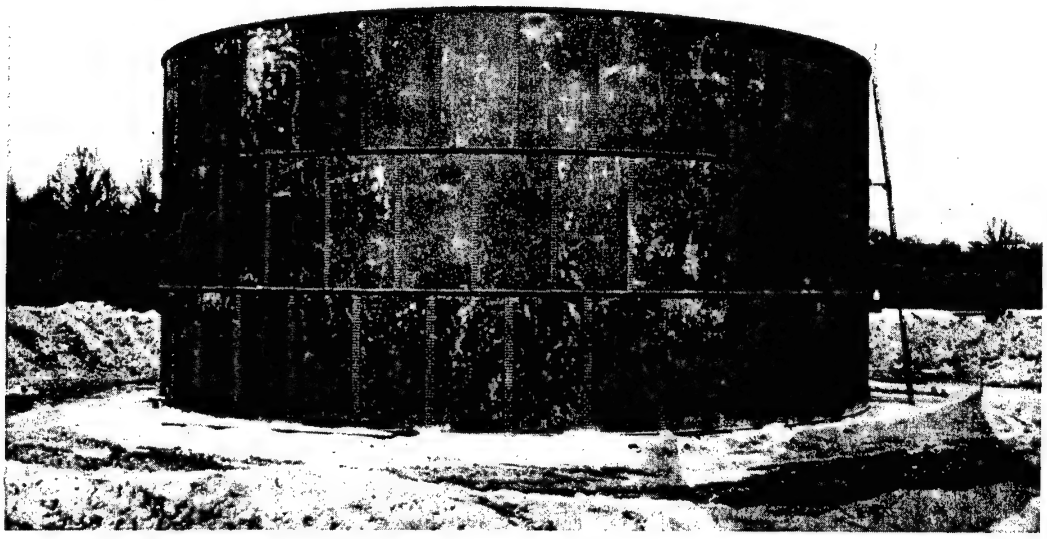
Drum Cleaning and Filling Machine. During FY 1956 development work on a machine for mass cleaning and filling of 55-gallon drums was begun. A prototype has been designed and procured. The experimental unit consists essentially of a steam generator for supplying hot water, cleaning chambers with pumps, a leak-detecting trough, and apparatus for accurately filling two (2) drums at a time with exactly 53 gallons each. This machine, which has the capacity to clean and fill approximately 1000 drums in eight (8) hours and requires 12 to 14 men to operate, is now undergoing engineering tests.

This unit is expected to decrease greatly the time required for drum cleaning and filling, to reduce manpower requirements and to decrease contamination of fuel.

Rotary 5-gallon Can-Filling Machine. This unit, with a capacity of 10 cans a minute, has been developed and subjected to engineering and user tests. Test reports indicated that the performance of the machine was satisfactory but that the capacity should be doubled. Therefore, development of a new machine was undertaken. A prototype of the modified machine, which will retain many of the design features and operating characteristics of the original unit, but which will be able to fill at least 20 cans a minute, will be delivered in FY 1957.

Assault Support, Bulk Fuel Transfer, Storage, & Distribution System. It is necessary for the Army to have a system capable of supporting assault operations to permit resupply of liquid fuels in bulk from shallow-draft tankers moored offshore or from small tankers that can be beached. This system must contain all the elements necessary to facilitate the early establishment of bulk POL supply points on shore. Procurement of a prototype system is scheduled for FY 1959. The need for supplementary facilities has arisen as a result of the growth of daily fuel requirements of tactical elements, increases in tanker capacities, the necessity of conserving manpower, and the need to protect bulk fuel supplies from the effects of mass-destruction-type weapons.

A 50,000-gallon, collapsible, floating cell has been designed, and a 1/5 scale model prototype is nearing completion. The model will be subjected to marine testing, and procurement of two prototypes is



Fixed 10,000 bbl. bolted steel tank for fulk storage.

scheduled for FY 1958. Preliminary studies leading to the development of a 25,000- to 50,000-barrel cell for offshore floating or submersible storage have demonstrated the feasibility of this concept.

This developmental item will serve as the basic means of bulk fuel storage in support of tactical airheads which are supplied by long-range, high-capacity, water-borne aircraft. Terminal facilities incorporating this type of tankage are scheduled for procurement in FY 1960.

Preliminary studies and designs were initiated in FY 1956 for the development of a rigid submersible bulk-storage tank capable of being towed into offshore position by seagoing tugs or similar craft. Procurement of a prototype tank is scheduled for FY 1958; a terminal facility to support the use of this type of container is scheduled for procurement in FY 1961.

A complete family of bolted steel tanks ranging in size from 100- to 10,000-barrel capacity for use on shore, has been redesigned. These have been adopted as standard by both the Army and industry. A series of bolted aluminum tanks ranging from 100- to 1,000-barrel capacity has been developed, and service testing of them is nearing completion. The development of a standard design for a 55,000-barrel capacity welded steel tank, in both cone and floating roof type, is in the last phase. Another item in this line is a collapsible fuel cell in 10,000-gallon capacity, which has been completed and standardized.

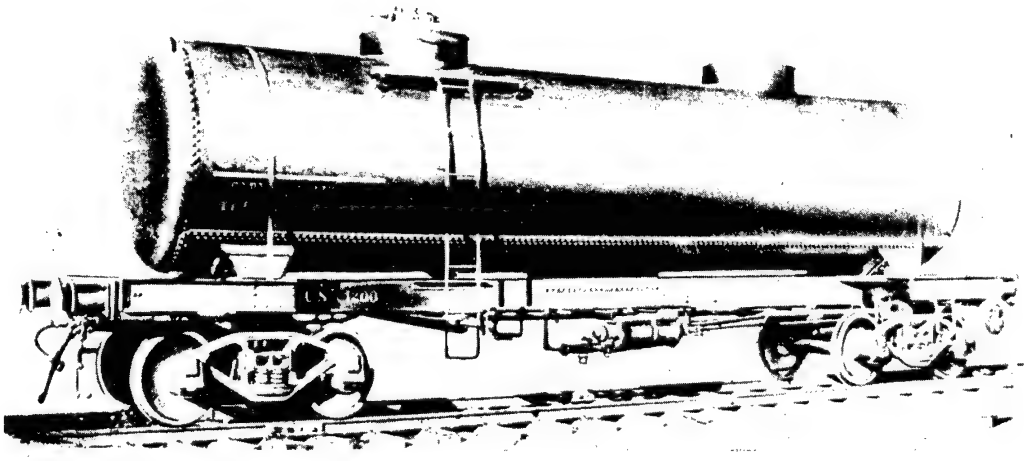
Ground Storage Container. In early 1945, work began on the development of a new technique of excavating a hole of predetermined size, placing a liner in the excavation, covering the opening with a secondary sheet, and in this way developing an "envelope" storage container. The lining material which was first used proved to be unsuitable. Since new fabrics are now available and design concepts have been improved, it appears that the original deficiencies can be overcome. However, techniques for crater excavation, consolidation, stabilization, de-watering, lining, and manifolding remain to be fully developed. The objectives of this project are to provide bulk storage facilities of large capacity which will involve a minimum amount of material, be capable of being installed rapidly, be amenable to dispersal and camouflage and provide bulk stocks with greater protection against the effects of mass-destruction-type weapons under the widest possible geomorphic conditions.

In order to lessen the time required for erection and to reduce the use of skilled welders in the installation of steel welded tanks, such as the newly designed 55,000-barrel capacity cone or the floating-roof bulk-storage type, a project has been initiated to develop tools and equipment to facilitiate the construction and use of the automatic girth and vertical seam welding machines. In the course of the development of these tools and items of equipment and the techniques for their utilization, it will be necessary to procure a tank for service test erection and preparation of necessary training aids. This work is scheduled for FY 1958.

PART II

POL CARRIERS

Railway Tank Cars (Foreign Type). Experience obtained from actual operations, knowledge of common failures, and reports of industry's problems in meeting production schedules have indicated that certain design changes are necessary to make railway tank cars suitable for foreign service. Designs of tank cars used during World War II consisted primarily of two groups of gages: the 56½-inch, and 60-inch and 66-inch group, and the 39 3/8-inch and 42-inch group. In order to have available railway tank cars that can be used on the various foreign railway systems, it has been necessary to develop 63-inch-gage and 36-inch-gage cars. Consequently, two standard and common under-frames for foreign railway tank cars were developed: one under-frame includes cars in the broad track gages of 56½-inch, 60-inch, 63-inch and 66-inch, and the other under-frame includes cars in the narrow track gages of 36-inch, 39 3/8-inch and 42-inch. The development of these common under-frames, designed for versatile application,



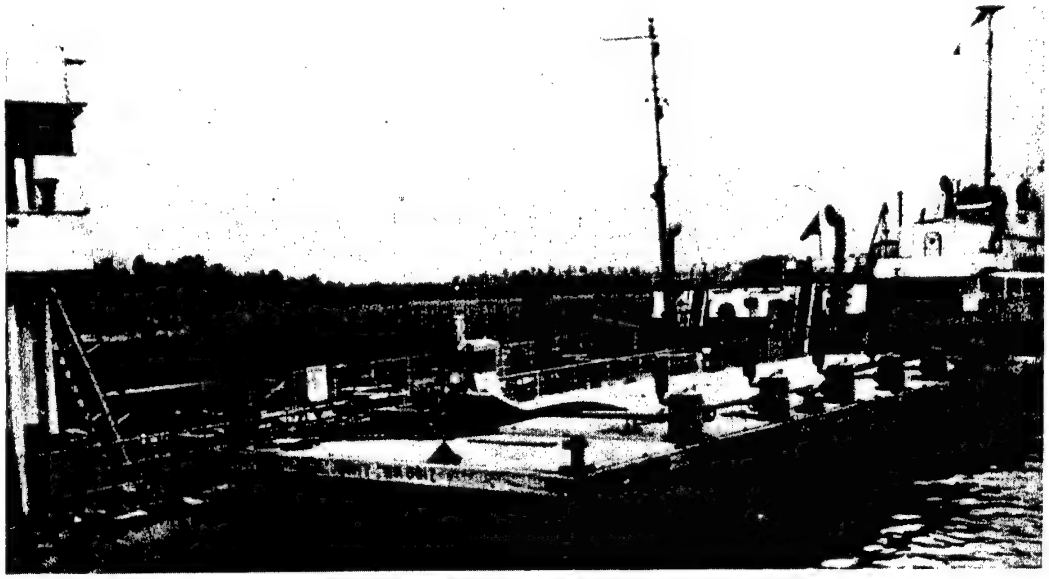
Petroleum tank car, 10,000 gallon capacity with adjustable features to accomodate various foreign track gages.

facilitates high-volume wartime production, reduces the number and types of under-frames required for fabrication, standardizes to the greatest extent possible component under-frame parts, and thereby reduces storage and shipping space requirements. A new feature of the tanks and under-frames that has been developed is welded construction. Also, weight has been kept at a minimum consistent with sound engineering practice and maximum military requirements.

Under these projects two tank cars have been standardized: the Railway Car, Tank, Petroleum, 56½-, 60-, 63-, and 66-inch gages, 10,000 gallons, 8 wheel, Foreign Service, 3 December 1953; and the Railway Car, Tank, Petroleum, 36-, 39 3/8-, and 42-inch gages, 6,000-gallon, 8-wheel, Foreign Service, 4 March 1954.

Barge, Liquid Cargo, Self-Propelled, Steel, 210 feet. To meet the need for a self-propelled barge suitable for use in transporting petroleum products on inland waterways, rivers, and harbors, an investigation was conducted to determine the most practicable military characteristics. Preliminary characteristics for this vessel were: 190-foot length, 33-foot beam, 13-foot loaded draft, twin-screw design, two 700-horsepower engines, and a cargo capacity of approximately 1000 long tons. In order to achieve the necessary cargo capacity it was necessary to increase the length of the vessel to 210 feet, beam to 38 feet, with the draft remaining at about 13 feet. Two cargo pumps for use in loading and discharging POL products were included. Also, in order to attain a high degree of maneuverability, twin rudders were installed. Specifications and drawings of this self-propelled barge have been completed, and the vessel is currently undergoing user tests, on the completion of which it is anticipated that this item will be classified as standard.

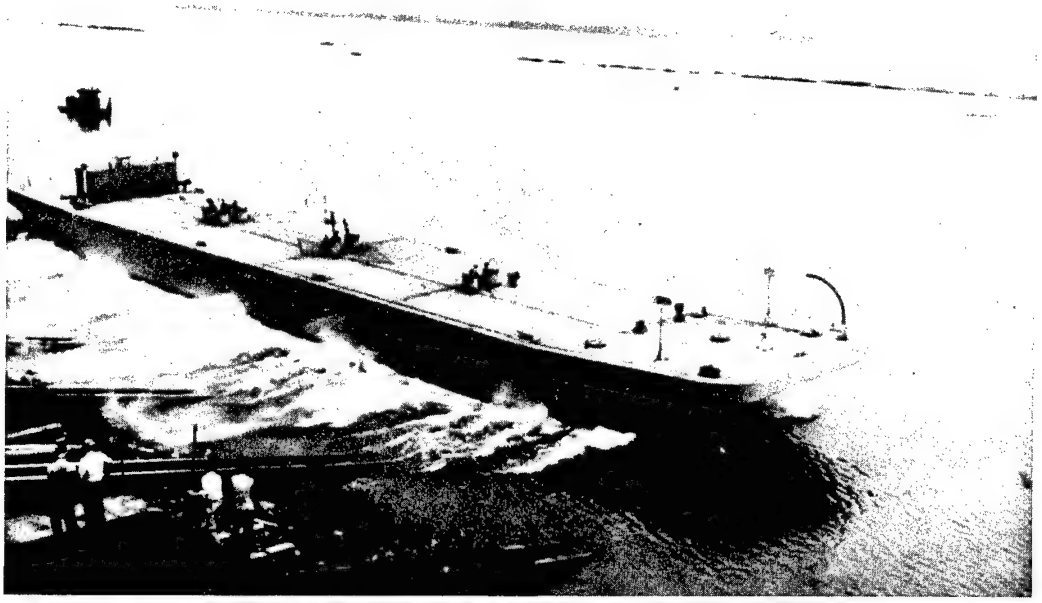
Conversion Kit, Liquid Cargo for 81-foot Nesting Barge. In order to facilitate more versatile use of transporting equipment, a kit for converting the Barge, Deck Cargo, on a propelled type, Steel, 81 feet long, to a liquid cargo barge for transporting liquid cargo on rivers and in harbors has been developed.



Kit for converting the Barge, Deck Cargo, to a liquid cargo barge.

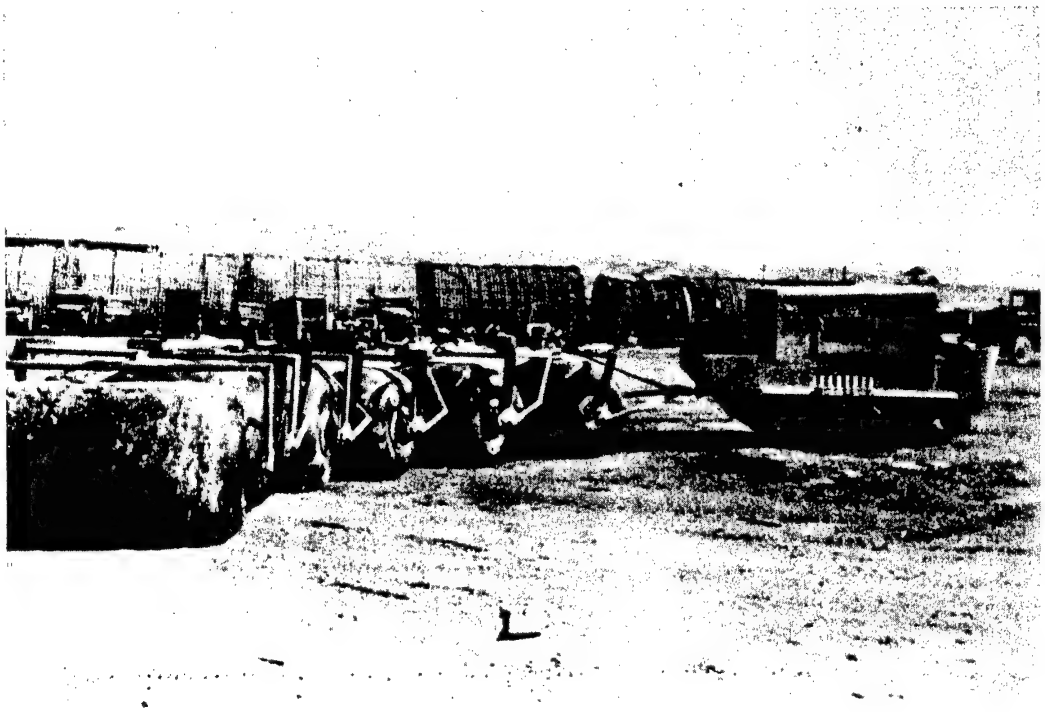
This kit can be easily transported by rail or freight on the barge. Components of this kit are pumps, piping, and accessories of suitable capacity for prompt and efficient loading and discharging of POL products. This conversion kit was classified as standard equipment on 1 March 1956.

Barge, Gasoline, Non-Propelled, Steel, 13,000 Bbl - 235 feet. This barge is intended to be used in transporting petroleum products on rivers, intra-coastal waterways and in harbors. The dead weight capacity of the barge is about 13,000 barrels; its overall length is 235 feet; and its draft is 8 feet 1 inch. The non-propelled barge was standardized 1 December 1949.



Barge, gasoline, non-propelled steel, 13,000 bbl.

Rolling Fluid Transporter. In an effort to explore and develop new methods of transporting fuel, experiments have been conducted with a rolling fluid transporter for possible use in carrying POL products across snow fields or other areas. Tests of the converted rolli-gon bags adapted with a towing rig indicated a rolling resistance of approximately 1/3 of the sliding resistance of sleds carrying drums of fuel over snow covered terrain. Currently, different types of rubber containers are being procured for testing, and rigs are being designed and fabricated for evaluation under all climatic conditions. If tests of the rolling fluid transporter indicates its suitability to military use, the items will be classified as standard.



Heavy duty rolling fluid transporter.

Cargo Aircraft, Fuel Carrying Equipment. The growing importance of fuel delivery to combat forces by aircraft resulted in the initiation of a study of this subject in FY 1955. This study has revealed that it is possible, using helicopters now in production, to transport efficiently large volumes of fuel to combat areas. Also, it has been demonstrated that existing helicopters can be converted into fuel tankers with minor modifications. Consequently the design and development of equipment for the conversion of Army aircraft into aerial tankers of optimum efficiency has been undertaken.

Semi-trailer, Gasoline-Tank, 4-Wheel, M131A1 (5,000 Gallons). This semi-trailer, which is capable of carrying 5,000 gallons of gasoline in a three-compartment steel tank, was developed in 1951 and 1952. When empty this vehicle weighs 15,300 pounds; when filled and connected to the Truck Tractor, M52, the gross vehicle train weight is 64,100 pounds. The latter weight unfortunately exceeds the allowable amount for operation on H-15 bridges. This semi-trailer is not fully acceptable to the field forces, but, due to an urgent need, a limited number of these vehicles are now being procured.

Semi-trailer, Gasoline, 4-wheel, XM131E1, 5,000-Gallon Capacity. This semi-trailer has an integral frame construction, which makes it lighter in weight than the production vehicle M131A1. It has been

designed to incorporate characteristics complying with the H-15 Bridge Formula, the various state laws (so far as practicable) and I.C.C. regulations. The tank of 5,000 gallon capacity (plus 4% overage for expansion) is divided into four compartments of 1,250 gallons each. A lightweight suspension ("Newey" type) instead of the heavier standard Ordnance suspension is used. The cabinet for housing pump and engine assembly, mainfolding valves and outlets is located on the curb side of the vehicle. Provisions are made on the left side for future installation of a cabinet to house an integral filter system should this vehicle be used for refueling Army aircraft. Prototypes of this semi-trailer are now being tested.

Semi-trailer, Gasoline Tank, XM131E2, Aluminum, 5,000-Gallon Capacity. This vehicle has an integral frame-tank structure of aluminum construction, and is specifically designed to comply with the H-15 Bridge Formula and I.C.C. regulations. It is also expected to meet the requirements of a majority of state laws governing the length and weight of semi-trailers and the transportation of explosives or other dangerous articles in motor vehicles on highways. The gasoline tank, which has a capacity of 5,000 gallons plus a 5% overage for expansion, has four compartments of 1,250 gallons each. Features of this developmental semi-trailer include suspension, valving, piping and other components of lightweight design. Ordnance standard brakes, axles, and standard parts, a pump rated at 250 gallons per minute and a 250-gallon-per-minute integral filter system for Army aviation refueling needs. This vehicle will be the lightest semi-trailer for carrying 5,000 gallons of gasoline that has been developed to date by the Army.

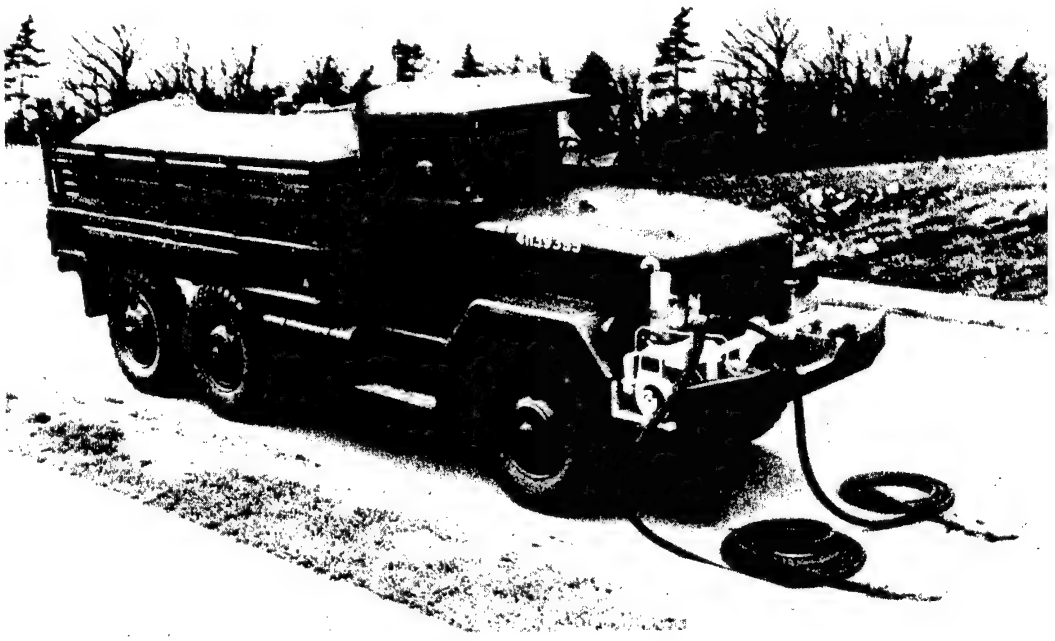
Rolli-Tanker. Developmental work to produce a rubber Rolli-Tanker capable of hauling 250 gallons of fuel is progressing. This item, which consists of a 40 x 60 x 10 inch cylindrical rubber roller complete with a towing harness, can be towed by most pintle-equipped vehicles. Results of the first phase of tests in 1956 indicated that the Rolli-Tanker can be used successfully to haul fuel and other liquids, and can handle capacity loads when operated on generally level terrain. Rolling resistance was low on level ground, but the stability of its tested configuration was a speed-limiting factor. It was found that when a Rolli-Tanker of this configuration was operated at certain speeds, instability and violent lateral rocking action resulted. The stability was improved, however, by operation at less than maximum capacity and at a reduced pressure. Further investigation is planned to determine the effects on stability of varying the configuration of the tanker, and to devise a method of emptying the Rolli-Tanker completely without collapsing.

Fuel Supply Trucks - Conversion Kits. During World War II and the Korean conflict military vehicles were refueled essentially by 5-gallon cans and, in some instances, from fuel stored in 55-gallon drums in conjunction with hand-operated pumps. This method, often referred to as the "packaged concept" when utilized as the basic refueling method, proved to be inefficient for several reasons. It requires an enormous supply and re-supply of cans and drums; excessive manpower in packaging and delivery; too much time

is consumed in refueling vehicles; reconditioning plants are required; a large number of vehicles have to travel back and forth between combat areas and supply points; considerable fuel is wasted during refueling operations; quality control of fuel contents is difficult to maintain due to excessive handling.

Since the use of military vehicles has increased, and fuel consumption by the vehicles has risen greatly, a revised and more efficient distribution system is of the utmost importance to assure the availability of fuel for the using vehicles as dictated by the tactical situation prevailing.

In keeping with military emphasis on delivering fuel to the using vehicle from bulk fuel carriers incorporating dispensing equipment, studies were undertaken to determine whether special-purpose vehicles

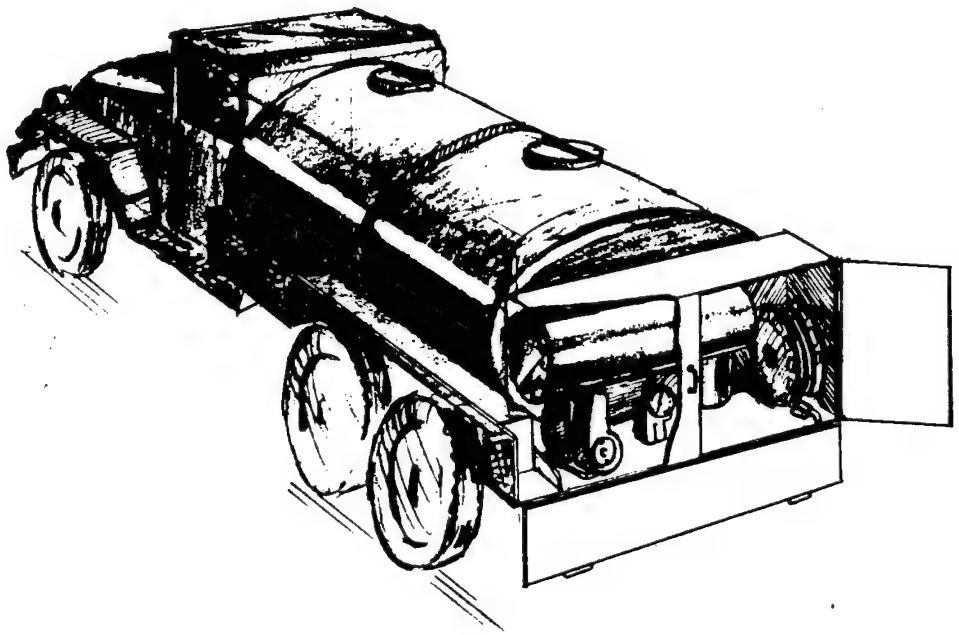


Fuel dispensing kit with front-mounted pump (1200-gallon capacity) to facilitate bulk delivery of POL products to using vehicle.

should be developed or the existing series of military vehicles should be utilized for this purpose. Since the supply of fuel to a combat area is a variable, and since Department of Defense doctrine discourages the placement into the system of additional specialized vehicles, it was decided to utilize the existing series of military vehicles. Currently, extensive

experimental work is being done in the development of conversion kits for the 2½-ton series of military trucks. Various types of conversion kits for these trucks are now being designed and evaluated. The Seventh Army in Europe has performed considerable initial development work in this field. Essentially, this design consists of two (2) 600-gallon, skid-mounted steel tanks set on the cargo bed of the truck. The dispensing equipment consists of a 30- or 60-gpm pump, which is mounted on the front end of the truck and utilizes the power takeoff shaft normally used for operation of the winch.

In order to assure the availability of adequate pumping capacity when dispensing fuel to the using vehicles from the dispensing kits, consideration is being given to pumping equipment having capacities in the range of 50 to 200 gpm. In order to minimize conversion time to optimum arrangement, gasoline-driven pumps, electrically-driven pumps and other power sources available on the vehicles are being evaluated. These higher-capacity pumps will permit the simultaneous refueling of two or more vehicles. Consideration is being given to the inclusion of filter-water separators, meters and hose reels, as parts of the dispensing kit. In order to satisfy air transportability requirements for this equipment,

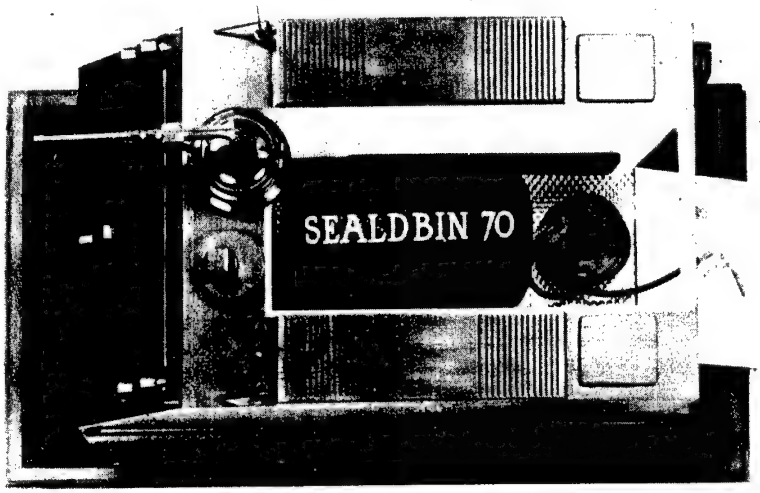


Fuel dispensing kit 2½-ton series truck rear-mounted dispensing unit, 1200-gallon capacity.

it is being designed as light as possible. Prototype tanks of aluminum and magnesium are being developed and these light metals are also being utilized for the dispensing equipment where possible. In the development the geometry of the tanks are being changed to allow space for the dispensing unit on the rear of the truck.

Incorporated in this development is a family of cargo kits suitable for converting vehicles such as the M-59 personnel carrier into a bulk fuel tanker. This amphibious-tracked vehicle may be used as a fuel transporter, specifically in terrain where $2\frac{1}{2}$-ton trucks are incapable of operating - for example, in the fording of streams or rivers when barges are not available, or where bridges are non-existent. Characteristics of the M-59 indicate that this vehicle can support a total gross weight of 3100 pounds in the floatation position. This gross weight represents approximately 500 gallons of fuel. Emphasis for conversion kits for these vehicles is being given to simplicity and light weight design.

A model of this vehicle has been fabricated, and the following arrangements have been considered feasible: 70-cubic-foot collapsible tanks filled to 500-gallon capacity, utilizing for the dispenser a 30-gpm, hand-operated pump.



Model of fuel dispensing kit for adaptation of M-59 personnel carrier to a bulk fuel dispenser.

It is anticipated that ultimately a family of conversion kits will be available for use on various types of cargo vehicles in order to make fuel available in bulk supply for the majority of prevailing conditions. This will eliminate the need for special-purpose vehicles and satisfy the requirements for a flexible system to be utilized in a manner dictated by the tactical situation existing. Prototypes of these conversion kits are expected during FY 1957.

Pillow-type Fuel Cell. One fuel cell with a capacity of 900 gallons has been procured. The exterior dimensions of this fuel cell when full of gasoline are as follows: length 9 ft., width 5 ft. 6 in., and height 2 ft. The weight empty is 180 lbs. and with 900 gallons of fuel is 5,670 lbs. This unit was tested in the bed of a 2½-ton truck. The truck with its fuel-cell cargo successfully completed 14,281 miles of pavement, gravel and cross-country operation. The results indicated that an ozone-resistant outer covering is required; also, a method of bulkheading the unit sufficiently to prevent surging of the fuel, stronger tie-down straps, and a better method of loading and unloading the cell when full are necessary. Another fuel cell eliminating the above deficiencies will be procured. The advantages of such a unit as this is that it can be packaged empty into a small space; it does not require a special-purpose vehicle; it can be used on the ground; and it may be buried in storage areas.

Self-sealing Auxiliary or Jettisonable Rubber Fuel Cells 55 Gallons. Tests of these items have revealed no deficiencies after 27,401 miles of operation and they are being continued. Several cells under test accumulated as high as 29,692 miles. Of the total of five cells tested, two failed in service due to the rupture of inner liners at high ambient temperatures at Yuma, Arizona. Additional development work on these items is therefore planned.

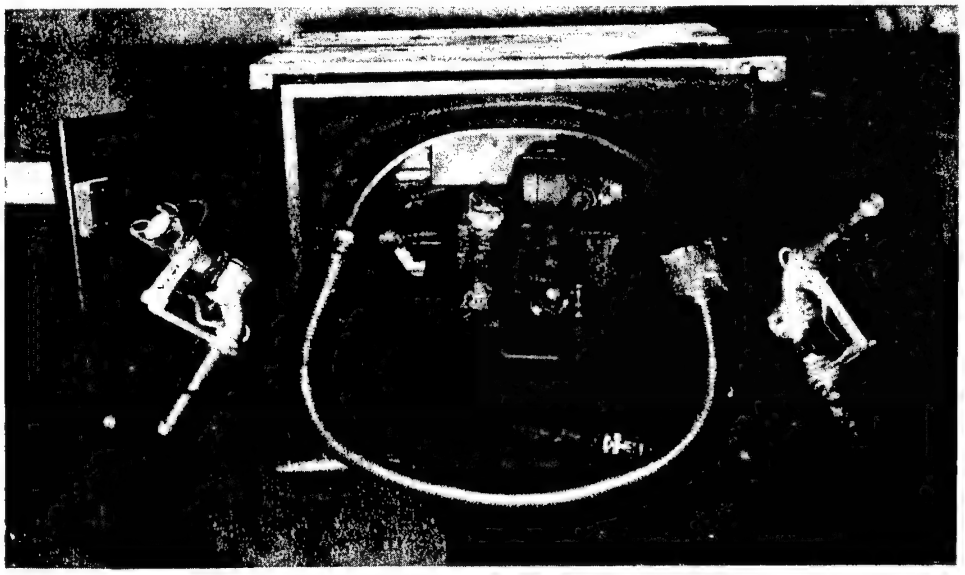
Non-sealing Auxiliary or Jettisonable Rubber Fuel Cells (55 Gallon Non-sealing). This fuel cell accumulated 48,168 miles after being tested during FY 1956. It also developed inner-liner deficiencies as in the case of the self-sealing type, and further work on the item is necessary.

PART III

DISPENSING EQUIPMENT

POL dispensing equipment of World War II was incapable of efficiently meeting the Army's ever-increasing military requirements for petroleum products. Power-driven pumps, hand-operated pumps, and dispensing nozzles proved to be inadequate. Moreover, excessive maintenance was required. A research and development program, undertaken to provide the Army with the best possible dispensing equipment, has succeeded in making available for military use a number of greatly improved items. Close coordination among the technical services is being maintained on dispensing equipment developments so that optimum efficiency and economy will be achieved.

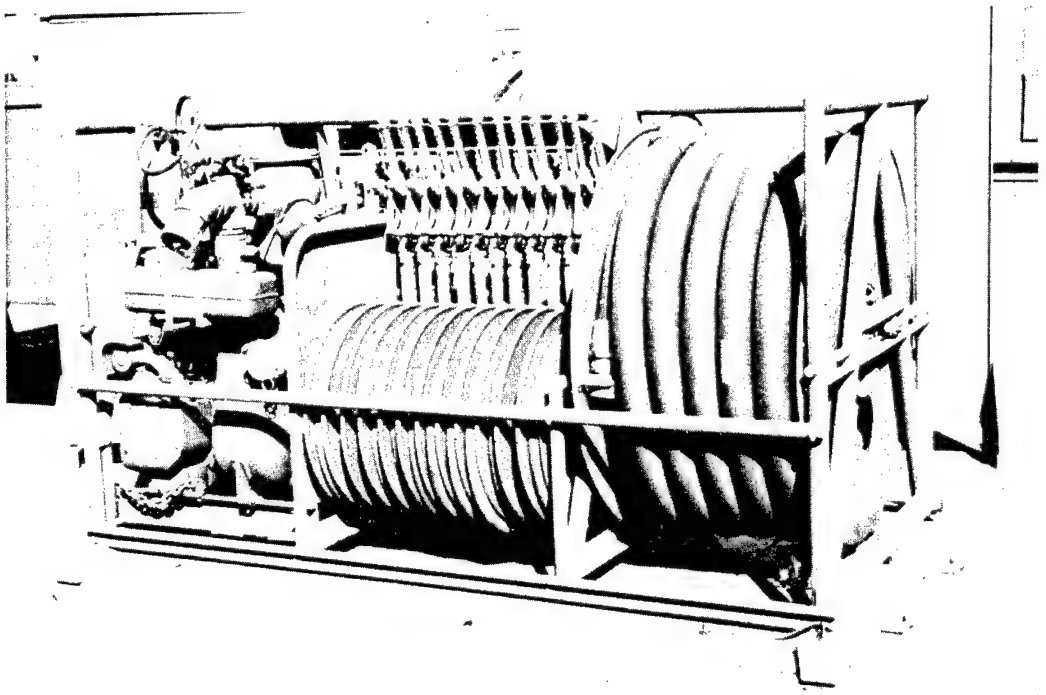
Power Pumps. Since large quantities of fuel are handled primarily in bulk supply it is necessary to have available a series of lightweight, high-capacity, mobile pumps in the range of 50-600 gpm. These must be capable of transferring and dispensing fuels speadily in a variety of tactical situations. These pumps will be used in dispensing fuel from bulk fuel carriers as well as from hastily-erected tank farms in rear combat areas.



Fuel dispensing pump, gasoline-powered,
50-gpm capacity for numerous field purposes.

A 200-gpm skid-mounted, pump-engine assembly, incorporating for its necessary equipment a meter, filter/separator, hose and hose reels, has been developed. A prototype of this item will be evaluated during FY 1957.

A 350-gpm pump-engine assembly, similar to the Marine Corps standard unit, will be subjected to tests during FY 1957 to determine its practicability and feasibility in Army field applications.

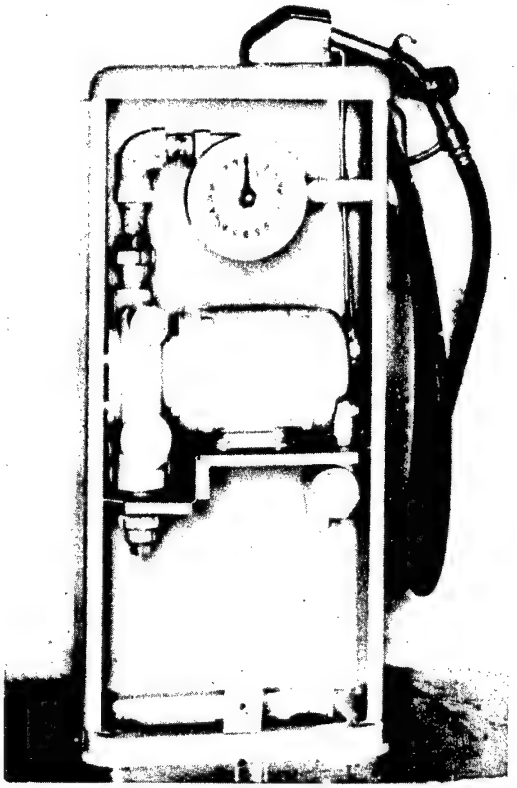


225-gpm pump for rapid dispensing of POL products in the field.

Hand-operated Pumps. Under certain field conditions, hand-operated pumps are desirable. The standard manually-operated, barrel-type pump utilized during World War II, however, was not entirely satisfactory for military use, because it broke down frequently and required considerable effort to operate. Since World War II, 15-gpm and 30-gpm pumps have been designed, developed and procured for field tests. These pumps are primarily intended for use with the 55-gallon drum and are equipped complete with nozzle for dispensing gasoline or faucet for dispensing oil. These pumps are also suitable for emergency use in transferring fuel to liaison-type Army aircraft. As a result of emergency tests, minor modifications of the 30-gpm pump are currently being made. Arctic climatic

tests of this item are also being planned in order to determine its acceptability under extreme cold conditions.

Service-Station-Type Dispensing Pumps, 12-15 and 22-25 gpm. Pumps of this category have been designed and developed to meet military requirements. Specifications for these pumps have been prepared and coordinated and they have become approved standard items of supply.



Service station type dispensing pump 15-gpm.

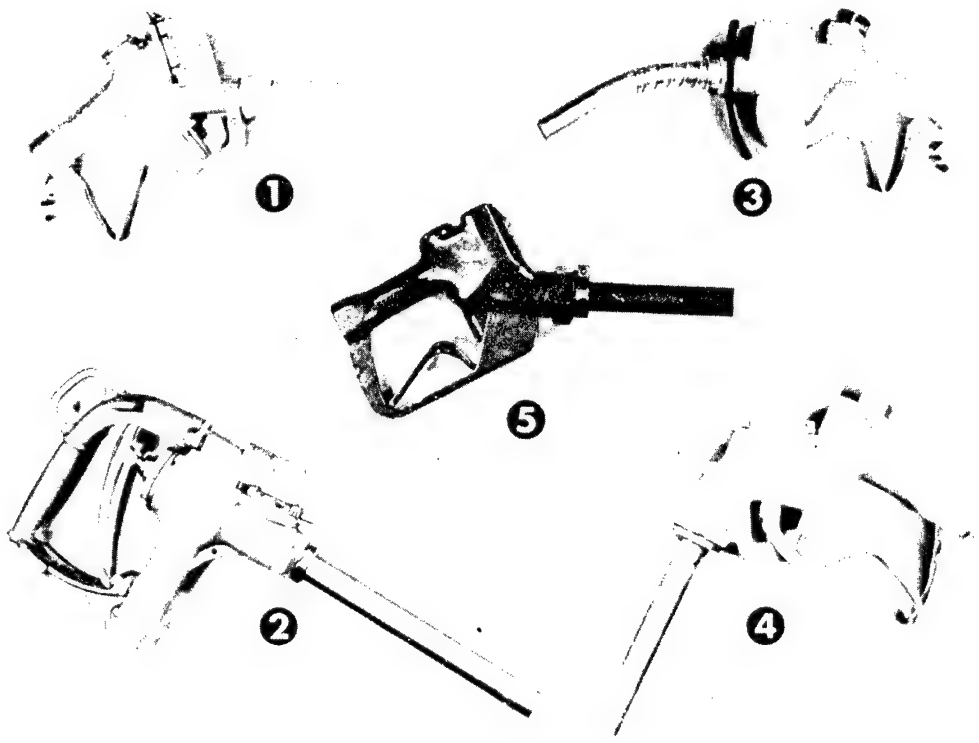
Aircraft Refueling Systems. The development of a variety of specialized equipment such as hydrants, pressure regulating and flow-control valves, liquid level controls, defueling pumps and filter/separators to meet the ever-changing needs for high-speed closed-aircraft refueling systems is continuing. Since World War II three separate types of hydrants and hydrant-coupler assemblies necessary to meet the ever-increasing requirements for a finer degree of fuel filtration and a drier fuel have been developed. Currently, newly-developed 300- and 600-gpm units are being procured in quantity for world-wide use.

Automatic Nozzles. A dispensing nozzle, which is capable of being shut off automatically and which can be used safely and economically even under blackout conditions, is a basic requisite in modern warfare. The use of non-automatic filling station type of nozzle has proved to be inadequate in filling 5-gallon cans, 55-gallon drums and vehicles from the standpoint of safety and efficiency. A project was therefore established to provide the Army with an automatic type of nozzle which would meet military requirements more satisfactorily.

A survey of commercially available nozzles, which was conducted several years ago, revealed that all failed to meet basic military needs. The development of a military automatic nozzle was therefore undertaken. While preliminary tests of the resultant prototype indicated that this nozzle met military characteristics, a small quantity procured for user tests proved to be unsuitable. It was found that the extremely close tolerances

required could not be maintained in production. Re-engineering of the automatic nozzle is therefore underway, and a number of the new models will soon be available for engineering tests.

Several commercial manufacturers are now producing greatly improved automatic nozzles and tests are underway to evaluate them for possible adaptation to minor military uses. Tests to date have been promising, although modifications have been required to permit cold weather operation. Type classification is programmed for FY 1958.



Automatic dispensing nozzles: 1. Buckeye 15-gpm nozzle, 2. Buckeye 50-gpm nozzle, 3. OPW 15-gpm nozzle, 4. OPW 50-gpm nozzle, 5. Reed (U.S. Army developed) 15-gpm nozzle.

PART IV

PIPELINES

Petroleum products pipelines revolutionized the logistics of supply of the vast volumes of liquid fuels consumed by the Armed Forces in all theaters of operations during World War II. Systems employed consisted of components hastily selected from commercially-available sources. This resulted in the introduction of numerous problems seriously affecting the design, construction, operation and maintenance of the resultant systems and their capacity to transport the required volumes of fuel. Future demands by the modern military machine will be considerably greater in volume and will involve an increased variety of fuels. The necessity for faster construction, greater flexibility of installation and operation, higher quality standards, and protection from the effects of enemy action is clear. Study and research and development are required on equipment and techniques essential to the construction, operation and maintenance of petroleum products pipeline systems suitable for use in any theater of operations. The lack of adequate equipment would make it impossible to logistically support tactical elements with vital supplies of liquid fuels required in conducting military operations, thereby gravely endangering the ultimate success of such operations.

Pipelines consist basically of pipe, valves, fittings, and pumps, but these are only part of a complete system. Flow- and pressure-indicating relief and regulating devices, gravity-detection equipment, scrapers, filters, separators and numerous other components are essential to an integrated system capable of multi-product operation.

Submarine Pipelines. Submarine pipeline sets in 6-, 8-, and 12-inch sizes are standard, as are offshore moving systems. Both have been modernized since World War II. The need for dispersion, greatly increased capacities to handle the newer types of super- and giant-type tankers, and the requirement for rapid replacement of destroyed terminals has necessitated the development of improved submarine pipeline construction equipment.

Facilities and equipment which will greatly reduce the time required to install offshore pipelines are needed. Capability of quick relocation or speedy replacement is an essential requirement. Current methods, involving the use of standard engineer items of construction equipment as well as many field-fabricated components, require excessive time, labor and materials. It is anticipated that many installation of this type with pipelines from 6 to 20 inches in diameter will be necessary. Work in this area has begun, and procurement of a complete set of equipment is scheduled for FY 1959.

Pipeline Pumps. To maintain higher output rates to meet the ever-increasing demands of pipeline capacities, high-pressure engine- and motor-driven centrifugal transfer-type pumps are being developed. These pumping

units will replace the now standard low-speed, low-head, centrifugal pumps developed during the period immediately following World War II.

A project is underway to develop high-pressure 6" and 8" trunk pipeline pumps. This equipment will permit maximum utilization of either the lightweight tubing or standard-weight line pipe for operating pressures in excess of 1000 psig. Higher capacities and pressures will permit an appreciable reduction in the number of pumping stations and in operating manpower requirements.

Prototypes of the 6" trunk pipeline pumps are scheduled for delivery in early FY 1957. It is anticipated that engineering tests and any additional modifications required will be completed in time to permit procurement of user test models as scheduled in FY 1959. Fabrication of the 8" prototypes will commence in FY 1957, and procurement of user tests models is scheduled in FY 1961.

In addition, development is proceeding on a high-pressure, 12" trunk pipeline pump. This unit is required to permit utilization of highly dispersed on-shore complexes and will be capable of pumping rates in excess of 4500 barrels per hour. Fabrication of the prototype is currently underway, with user test models scheduled for procurement in FY 1960. Units of this size and capacity must meet tanker off-loading rates and the development of on-shore complexes, but this pump has been designed to also permit use as a truck station pump for 12" size pipelines.

Indicator, Gravity, For Petroleum Products Pipeline, Radioisotope. Procurement of the prototype of this essential item of operational control equipment for engineering test is scheduled during FY 1956.

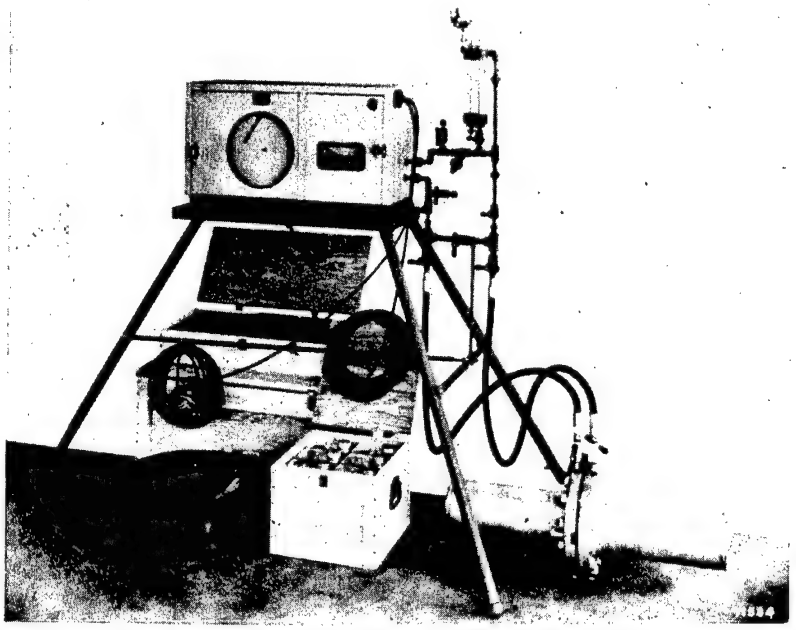
Operational Control, Pipeline Center. Final evaluation and troop testing is necessary on this item. Service test procurement is scheduled for FY 1957.

Automatic Pump Station Controls. Development of automatic control devices for the presently standard multi-unit type trunk pipeline pumping stations should reach the stage of procurement of user test models in FY 1957. These items are being developed in order to permit balanced pipeline operation at maximum capacity and with optimum safety. Concurrently, equipment will be required for the new high-pressure trunk-pipeline pumping units being developed, and for whatever type pump is finally selected for use with the hoseline-type pumping unit.

Special Pumping Units. Pumps designed for gas-turbine drive have been developed, but the lack of suitable prime movers has prevented complete testing and evaluation. The objective of this program is to design a very lightweight unit capable of ready transport by air or other means to remotely-located installations.

Nuclear-Steam Turbine, High-Speed Centrifugal Pump, 1000-gpm at 3000-Foot Head. This is a long range developmental item intended for high-pressure welded trunk pipeline service. The use of a small nuclear power plant is proposed as a means of conserving critical distillate-type fuel supplies.

Indicating and Recording Gravitometer. Work to date on a prototype has not been fully satisfactory. This unit is required to permit effective product control and to prevent contamination of supplies. It is scheduled for user test procurement in FY 1958.



Recording gravitometer for determining specific gravity of fuels.

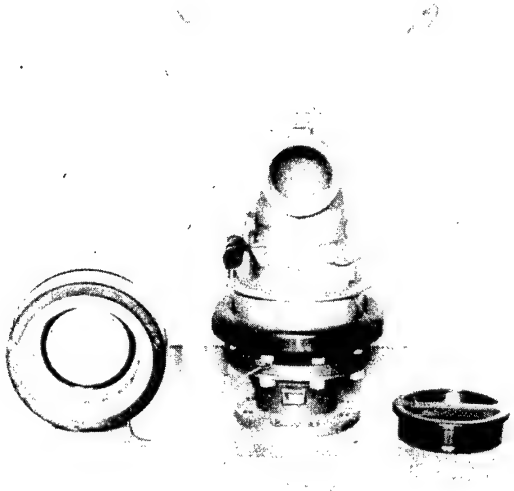
In-the-line, Fluid-Cooled, Seal-less Barrel Pump for Buried Installation. This long-range item is considered of major importance if effective protection is to be provided for booster-pumping installations. Initiation of prototype procurement is scheduled for FY 1961.

Hoseline Booster Pumping Unit. Development of a suitable hoseline booster pumping unit will be required if the flexible hoseline concept is adopted. Present experimental units are powered by a non-standard engine operating a high rpm in order to meet low unit-weight requirements. It is probable that a liquid-cooled engine will have to be used with resultant necessity for trailer instead of tubular frame mounting.

Piping. Work leading to the possible development of pipe and tubing which can be more readily and economically produced and installed must

continue along with work to improve the means of connecting successive lengths. Maximum utilization must be made of new materials (including reinforced plastics which could be used to reduce requirements for steel and field construction effort.)

Valves and fittings. Improved, lighter-weight valves and fittings are needed to reduce tonnage, cost, and installation labor requirements, and to provide a degree of standardization that will make field maintenance and repair of these costly items feasible. Preliminary work done to date has conclusively shown that commercially-available valves are over-designed and consequently excessively heavy and expensive.



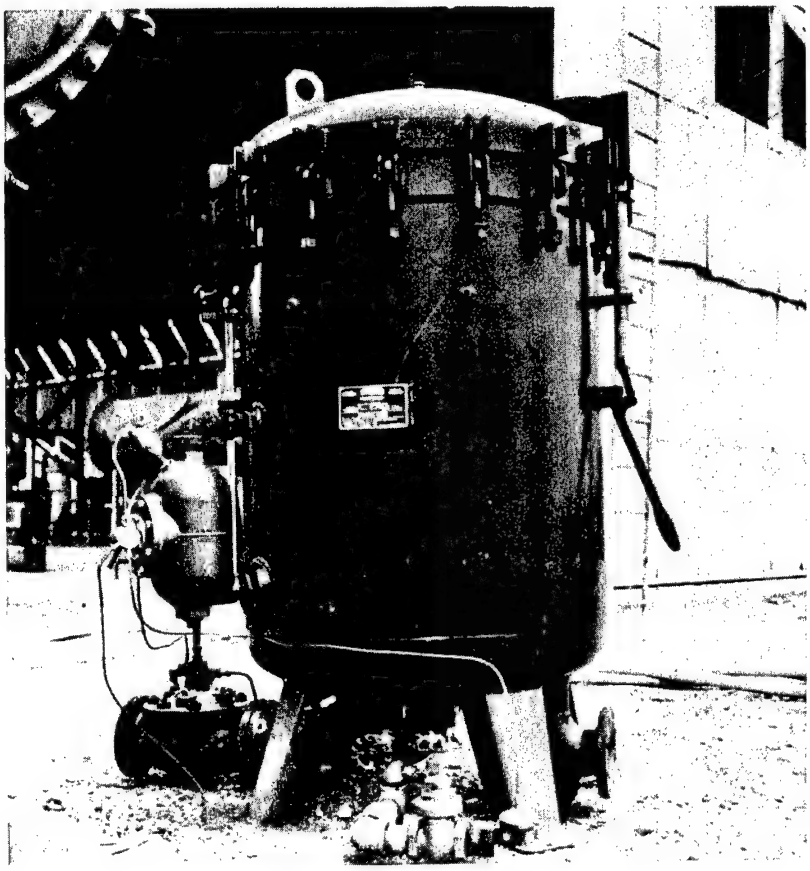
"Cla-Yal" quick coupler valve for use with pipelines.

Pressure Regulation and Flow Control. Equipment to effectively regulate pressures and control flow in all sizes of pipelines must be provided. Work in this area has begun. It is essential that components selected have the widest possible range of application in order to reduce the number of types to be stocked to an absolute minimum. As items are selected or developed and covered by adequate specifications, they will be incorporated into appropriate sets or facility type installation designs.

Water Separators and Filters. Although a vast amount of work has been done to meet the constantly increasing requirements for a high order of engine fuel filtration and water removal, even higher standards of quality are anticipated. Equipment currently being procured is not of a standard design. Consequently, the maintenance of spare parts and filtering media for all types has become an almost insurmountable problem. It is proposed to standardize the design to permit complete interchangeability and to effect an enormous saving in both initial and maintenance cost.

Flow Control. Meters for indicating and recording flow rate are essential for effective operational control. One type of differential-flow meter with a built-in gravity compensator is now being readied for engineering tests. Other meters of the indicating and totalizing type

primarily for quality control purposes and suitable for field use will be required. Commercial types are costly and would be impossible to effectively maintain in the field.

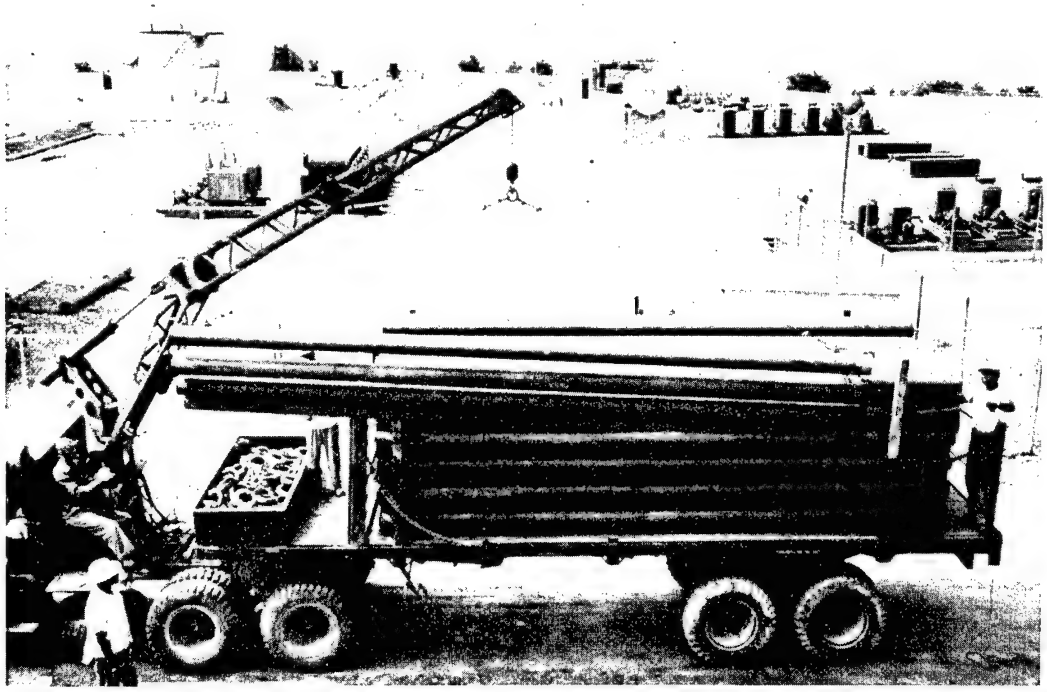


Water separator and filter (Bowser). Separator for removing water and filtering fuel.

Construction Equipment. Commercial pipeline construction normally involves large diameter lines which are carefully formed, joined, coated, wrapped and tested before being carefully lowered into a deliberately-prepared trench. Permanence, not speed of construction, is the primary objective. Commercially-available equipment and tools are not fully suited to meet military requirements. Consequently, a complete pipeline construction truck, a power-operated field type grooving machine, and sets of tools designed to substantially increase the construction potential of field units, have been developed and standardized. Work on the development

of a field portable pipeline tubing bender and a plow-type pipeline ditcher did not prove to be successful and was therefore stopped. Numerous small construction and material handling aids have been developed. Techniques and procedures for many construction and maintenance tasks designed to increase the productivity of troop units have been devised.

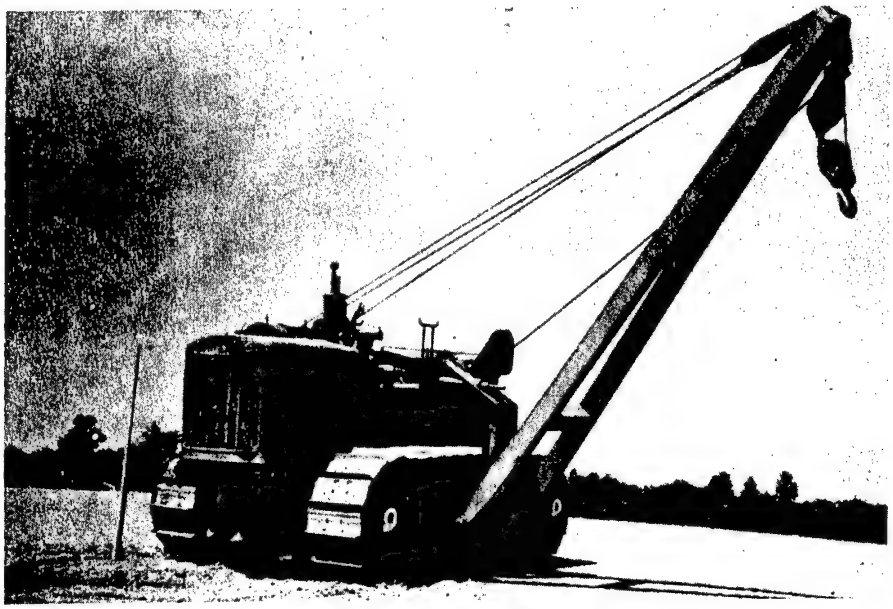
Pipe Transporter. Over 90% of the tonnage in a pipeline system is the pipe proper, and the handling and transporting of pipe in this quantity becomes very costly from the standpoint of manpower and time. A newly-developed type of pipe transporter with stringing boom, intended to facilitate the transporting and stringing of pipe or tubing, has been developed. This transporter, which employs a standard ordnance truck-tractor as prime mover, has satisfactorily passed all engineering tests. Because of fund limitations this unit is planned for procurement for troop testing in FY 1958.



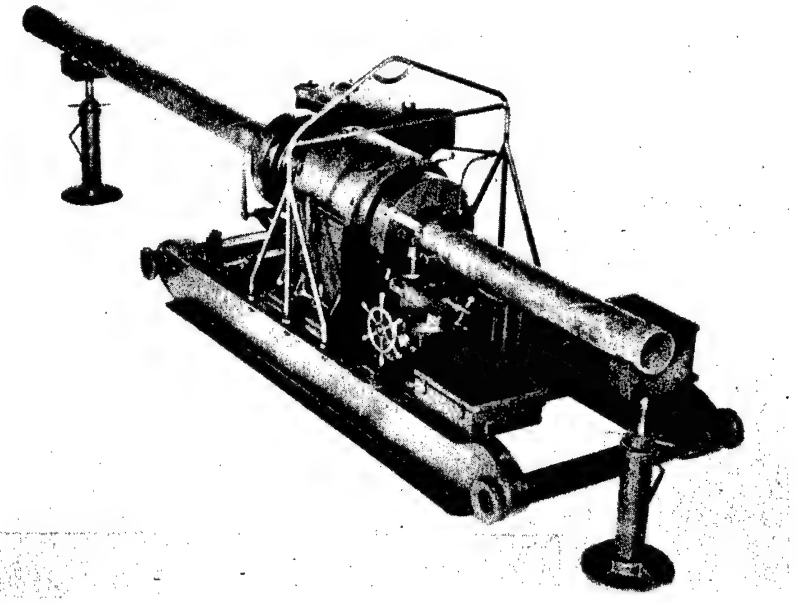
Pipe transporter and loading derrick.

Pipelayer. A suitable track laying pipelayer capable of handling long strings of 8- through 20-inch pipe is required. During World War II a conversion kit was utilized, but new industrial developments have conclusively proven the advantage of the properly-designed unit over the kit concept. It is proposed to procure a newly-developed commercial type unit for engineering and user tests in FY 1957, when the manufacturer completes

field testing of the prototype. It is also proposed to procure for simultaneous test a set of pipe bending shoes designed for use with the new pipelayer.



Pipelayer.



Pipe-Cutting & Grooving Machine.

Pipe-Cutting Machine for Hazardous Locations. A mechanical device, suitable for use in cutting out damaged sections of pipe where potentially hazardous accumulations of explosive vapors will exist, is necessary in order to facilitate rapid repair. A commercially-available type is scheduled for procurement in FY 1957. It is probable that this machine will require considerable modification.

Buried Pipeline Construction Equipment. Machines capable of high-speed ditching operations have been developed and adopted for military use. It is believed that pipelines in port or other base areas of high population density can best be protected by being buried at depths of from 4 to 6 feet. To undertake this type of construction, special machines such as cleaning and priming, tar-kettle, coating and wrapping, road boring, benders and trench backfillers will be required. It is proposed to carefully evaluate commercially-available types, and procure engineer and user test models for detail evaluation. From the results of these tests appropriate specifications data can be established to permit procurement for military use.

Automatic Pipe-Welding Machine. The anticipated requirement for welded and buried high-pressure pipelines is such that construction rates attainable by manual welding methods cannot be accepted. The probability of obtaining qualified welders in any reasonable number is so remote that an investigation has been made concerning the possibility of developing a machine capable of automatically and rapidly joining successive lengths of line pipe by welding. Such a machine could be developed, but, to date, funds to undertake this work have not been made available. Since it is expected to take considerable time to complete the development of this item, it is planned to initiate work promptly.

Pipeline-weld Inspection Equipment. To prevent costly loss of operating time, all welds on lines involved in water-course crossings or offshore submarine lines, should be completely inspected prior to installation. The use of portable x-ray equipment similar to that used commercially is deemed essential. Prototype mobile equipment is scheduled for procurement in FY 1958.

Depot-type Tubing and Pipe-reclamation and Reconditioning Plant. A facility capable of cleaning, straightening and repairing pipe and tubing from 4- through 12-inch size is considered essential if maximum utilization of this critical item of supply is to be achieved. Lines will have to be taken up and moved as operations progress, and rehabilitation prior to reuse is essential. Such a reconditioning plant is scheduled for development in FY 1959.

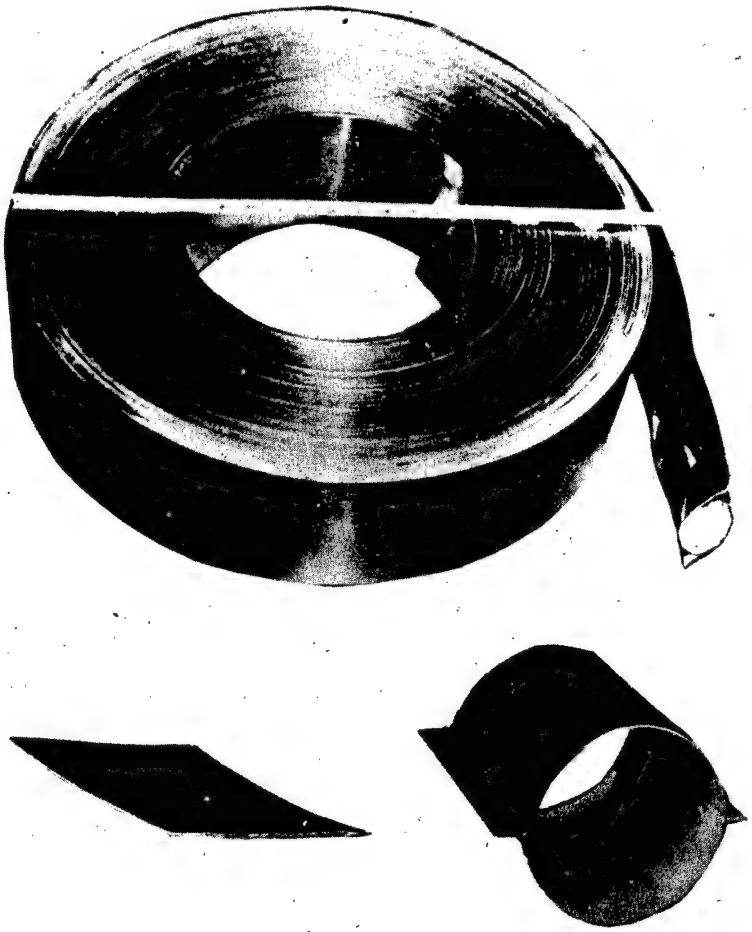
Theater of Operations Pipeline Tubing Mill. Based on an investigation that indicated the feasibility of developing a portable field-type mill capable of producing pipeline tubing from large coils of steel, a preliminary specification, which could be utilized for prototype development,

has been prepared. With the use of such a mill, in lieu of shipping fabricated pipe or tubing, a saving of more than 75% in ship tonnage requirements could readily be achieved. Procurement of a prototype mill is now scheduled for FY 1960.

Assault Bulk Supply System. Additional work on the flexible hoseline system, which will be determined by the results of full-scale maneuvers such as Sledgehammer, will be accomplished. This will not only include the on-shore bulk facilities, but those required to off-load cargoes from special bulk tankers. The feasibility of utilizing a system such as the flexible hoseline for extending the forward turminus of the rigid-type pipe head will be studied.

Lightweight Flexible Pipeline. Although most of the items essential to this system have been developed, additional work is required to provide all of the items essential to a completely-integrated system. Many commercially-available items currently being utilized are unsuited for field use, or are excessively heavy or costly to produce and operate. It is proposed to complete work on this system while simultaneously developing the equipment for the high-pressure type fixed pipeline system.

High-Pressure Fixed Pipeline System. Development of the many items and facilities essential to the high-pressure fixed-type pipeline



Experimental Tube-In-Strip for temporary rapidly-established pipeline distribution system.

systems is to continue so as to insure early availability. This work will be carried on concurrently with that of the assault and flexible type systems.

Tube-In-Strip. Since the transporting of fuel by means of pipelines has proven to be extremely efficient, the feasibility of extending the pipeline into forward combat areas connected to either the main pipeline system or to hastily-erected bulk storage facilities in or near combat areas has been studied. Such a system would provide a flexible supply of fuel with a minimum of manpower requirements. An industrial product, which may be applicable to the above purpose, has recently been found. This is aluminum Tube-In-Strip, which is fabricated by incorporating a layer of friable, chemically-inert material within an aluminum casting and then rolling the casting into flat sections of desired length and width corresponding to desired diameter. After the tubing is uncoiled on the ground a minimum liquid pressure supply is required to fully inflate the tube to the usual shape of tubing and piping.

Tube-In-Strip is an ingenious approach to a special problem, achieving reduction in cost, weight, and cubage for storing or shipping. This product is compact when deflated, is adaptable to any terrain, is not affected by lower temperature and is easy to handle. It is believed that this tubing can be efficiently laid in forward areas with a minimum of personnel due to its lightness and compactness.

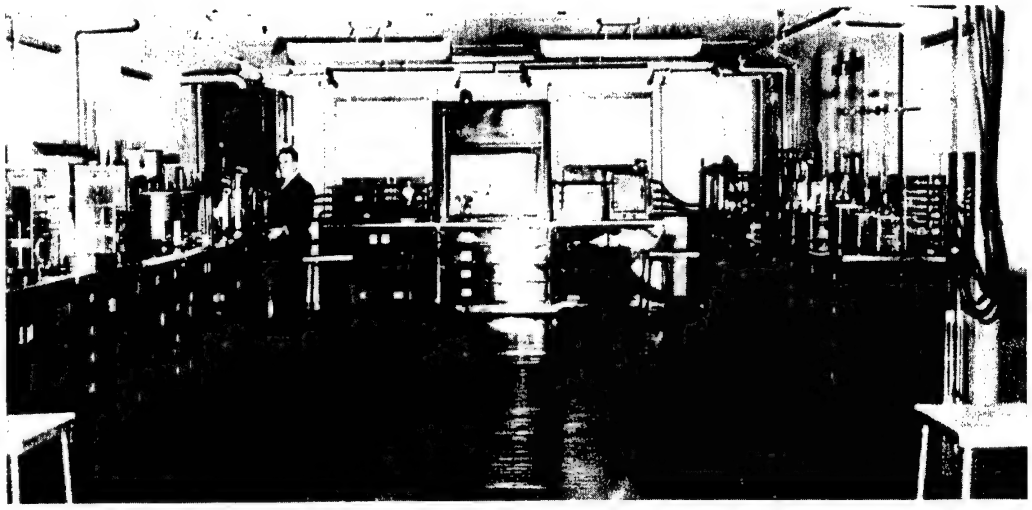
PART V

QUALITY CONTROL OF POL

All petroleum products must be carefully inspected for quality from the point of procurement to delivery to consuming units, to make sure that they conform to military specifications and are suitable for use in military vehicles. At the point of procurement, inspection of quality may be accomplished by either civilian or military agencies, utilizing facilities which are normally provided by the oil company from which the petroleum is procured, or in special military laboratories available for this purpose in the Zone of the Interior. Once POL products are loaded aboard ocean transports, all subsequent inspection is performed by military personnel in laboratories specifically provided for this purpose.

During World War II, military petroleum testing laboratories were generally of an improvised nature, hastily assembled to meet situations which arose in the several operating areas, and they were not found adequate in all respects. Since World War II considerable research has been conducted to develop and standardize testing facilities that are capable of meeting requirements under all types of operations in any theater. As POL product specifications are changed, the laboratory units must be modified and additional test equipment provided as required, so that the most effective quality control can be maintained by the Department of the Army.

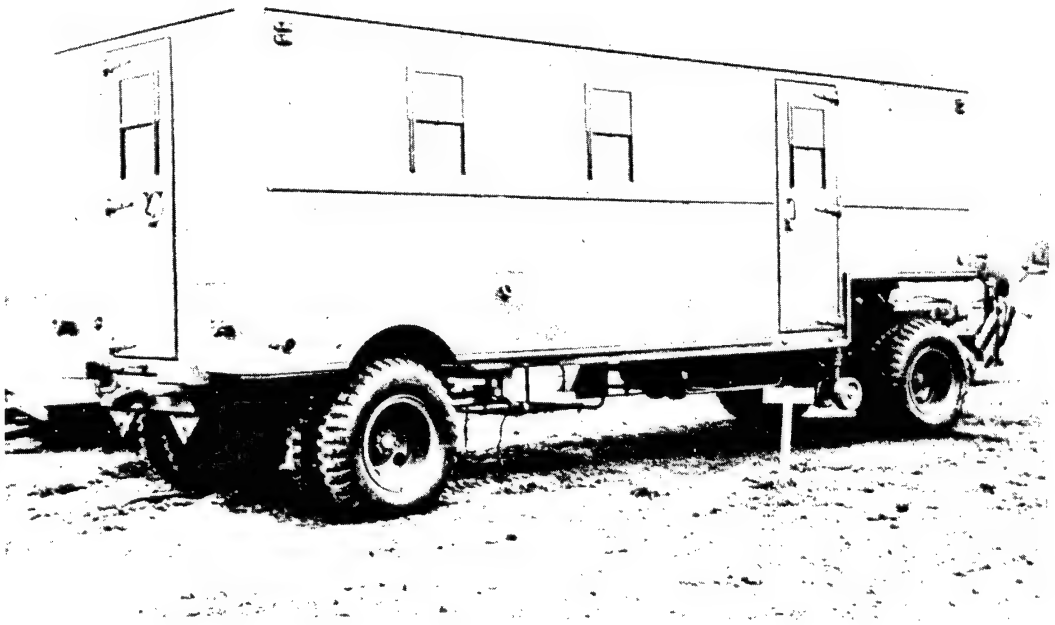
Base Petroleum Laboratory Assembly. This facility consists of a number of sections, complete with testing equipment, which can be erected



Base petroleum laboratory at a fixed installation.

in a period of 8 hours at a base or stable area. Emphasis has been placed on the development of two additional units for this laboratory. These are: a. the Low Temperature Apparent Viscosimeter, for use in determining the apparent viscosity of lubricating greases under temperatures down to minus 100F, and b. a Steam Jet Gum Apparatus, to be used to determine the existing gum content in motor and aviation fuels. Prototypes of these experimental items are expected during the latter part of FY 1957.

Mobile Petroleum Laboratory. The Mobile Petroleum Laboratory was developed for quality evaluation and identification of friendly and

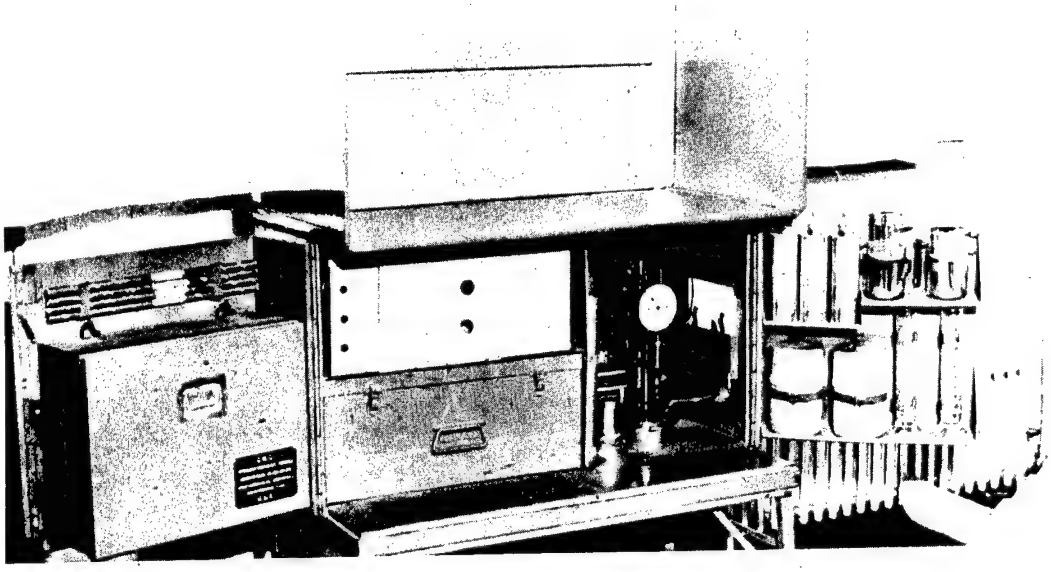


Mobile Petroleum Laboratory for field operation.

enemy petroleum products. It was designed for compactness, mobility and air transportability and is equipped with major testing apparatus, chemicals and hundreds of items of miscellaneous glassware and spare parts. It is also equipped with an air compressor, vacuum pump, water circulating pump, gasoline heater, air, gasoline and water storage tanks and utility lines for air, gas, water, drain and electricity. This unit was accepted as standard in February 1949.

Since the laboratory was first adopted as a standard unit, numerous improvements have been made in testing equipment and storage facilities. The gasoline heater was replaced by an electric heater, a CRF (Coordinating Fuel Research) Fuel Testing Engine and an air-conditioning unit were added in order to broaden the scope of operation. The mobile unit is a component of the parent Base Laboratory and is usually assigned to an Army activity in forward areas.

Petroleum Testing Kit. The petroleum testing kit was developed for rapid evaluation of petroleum products in the field and at storage depots.



Portable Petroleum Testing Kit for field use in determining quality of fuel.

It was designed as a lightweight and compact unit and is equipped with measuring, gauging and sampling equipment and spot testing apparatus. It was adopted as a standard item in 1952. Since its adoption minor modifications have been made to the stand assembly for additional strength and support.

Lightweight Knock-Testing Engine. This developmental item is intended primarily for use by forward units to test the octane rating of fuel. The engine is also expected to be used in the Base Laboratory. Results of a study completed during FY 1956 to establish the feasibility of utilizing this engine with a minimum of accessories for obtaining super-charged fuel ratings were satisfactory. It has been determined that

the lightweight knock-testing engine - without standard dynamometer fuel- and air-measuring equipment - is suitable for testing the octane rating of aviation fuels. This lightweight and less complex engine will permit greater flexibility in use and greater efficiency in operation.

PART VI

MISCELLANEOUS POL EQUIPMENT

Bulk Delivery of Fuel by Aerial Drop. Aerial delivery of fuel to combat forces is an increasingly important function in modern warfare. Accelerated efforts in developing adequate techniques for the successful delivery of POL supplies by aerial drop were made during FY 1956. During FY 1957 a preliminary technique has been developed for dropping collapsible Sealdbin containers filled to a capacity of 525 gallons and rigged to a platform and parachute assembly. This technique has been further refined by effecting a successful drop with the container attached to a parachute without the use of a platform. In addition two (2) 70 cubic-foot Sealdbins were subjected to hydrostatic tests. One unit failed at 38 psig, and the other at 45 psig. These results are encouraging, and further work in this area is being continued to determine the extent to which Sealdbins can be used for the bulk delivery of POL products by aircraft.

Sealdbins ranging from 375- to 2775-gallon capacity for aerial delivery of POL products.

In addition to the development in aerial delivery of fuel in bulk, it is considered necessary to develop techniques for aerial drop of dispensing equipment in order to facilitate efficient distribution of the fuel. Therefore, preliminary plans for air dropping the 50-gpm and 225-gpm dispensers have been completed.

The development of satisfactory techniques for the aerial delivery of POL supplies involves numerous complex problems. The utility of aerial drop methods is obvious, however, and work on the development of an optimum system for use under combat conditions is continuing.

Aircraft Refueling Systems. Development of a variety of specialized equipment such as hydrants, pressure-regulating and flow-control valves, liquid-level controls, defueling pumps and filter-separators is continuing in order to meet the ever-changing needs for high-speed closed-aircraft refueling systems. The ever-increasing requirements for a finer degree of fuel filtration and a drier fuel have led to the development of three separate types of hydrants and hydrant-coupler assemblies since World War II. Two complete phases of development in this area have occurred: 300- and 600-gpm units for fixed and portable field use have been developed and are being procured in quantity for world-wide use.

Prefabricated, Segmented, Tanker Unloading Pier. Preliminary studies indicate that development of a prefabricated pier is feasible, capable of being towed into position, and made operational in a period of 24 to 48 hours following arrival at the site. This unit will facilitate rapid establishment or restoration of port facilities and permit the unloading of tankers at the required rapid rates. It will incorporate all essential piping, pumping and other equipment. Procurement of prototypes of the prefabricated pier is scheduled for FY 1961.

Equipment Sets. In the past, tank farms with all essential appurtenances, bulk plant installations, pumping stations and unloading facilities were constructed on the spot and tailored to meet requirements. This method was inadequate and very costly. It necessitated extensive maintenance and required very large spare parts inventories for individual installations. To overcome this, equipment sets, providing all elements necessary for the functional system, have been designed. This, in turn, will standardize installation designs and provide more effective means for project planning and stock control. To date, approximately 20 equipment sets have been developed and standardized and a number of specifications written. Work has been initiated on over 25 additional sets, some of which are still undergoing user tests. Nine additional sets of equipment are scheduled for development through 1961. The development of these equipment sets will generate additional needs for items which are not now commercially available. These must be developed and covered by detail specifications to insure effective procurement.

Rehabilitation of Production and Refining Facilities. A continuing desk study is being carried out in these areas to insure that information about developments in these fields is kept up-to-date. From these studies recommendations for the design and construction of stand-by floating refineries, intended to provide essential production capacity to replace destroyed facilities, have evolved, but no action in the near future is contemplated because of the great cost of such a program.

Special Installation Designs. From time to time requirements arise which introduce basic problems of equipment selection and facility design. The bulk plant facility designed for installation on the Greenland Ice Cap is typical of such tasks. A complete facility was designed, procured, and shipped to Greenland in the Fall of 1956 and will be installed early in June of 1957. Facilities of this type, designed to support the construction and operation of distant early-warning stations on the ice cap, have been a difficult challenge. Such work will be continued in order that full and complete information on material, design, operations and maintenance problems is readily available. Assistance has been provided in the planning and design of complete systems for support of field operations where new concepts are being evaluated. It is anticipated that requirement in this area will continue.